Issued June 14, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 254.

A. C. TRUE, Director.

IRRIGATION RESOURCES OF CALIFORNIA AND THEIR UTILIZATION.

BY

FRANK ADAMS,

Irrigation Manager, in Charge of Work in California.

PREPARED UNDER THE DIRECTION OF

SAMUEL FORTIER,

Chief of Irrigation Investigations.

[Based on work done in cooperation between the Office of Experiment Stations and the Conservation Commission of the State of California.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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OFFICE OF EXPERIMENT STATIONS.

A. C. True, Director.
E. W. Allen, Assistant Director.

IRRIGATION INVESTIGATIONS.

Samuel Fortier, chief.
R. P. Teele, assistant chief.

IRRIGATION ENGINEERS AND IRRIGATION MANAGERS.

A. P. Stover, irrigation engineer, in charge of work in western Oregon.
C. E. Tait, irrigation engineer, in charge of work in southern California.
S. O. Jayne, irrigation manager, in charge of work in Washington.
Frank Adams, irrigation manager, in charge of work in California.
W. W. McLaughlin, irrigation engineer, in charge of work in Utah.
P. E. Fuller, irrigation engineer, in charge of work in Arizona and of power investigations.
W. L. Rockwell, irrigation manager, in charge of work in Texas.
Don H. Bark, irrigation engineer, in charge of work in Idaho.
Milo B. Williams, irrigation engineer, in charge of work in humid sections.
C. G. Haskell, irrigation engineer, in charge of investigations of use of water for rice irrigation in the Gulf States.
Fred G. Harden, scientific assistant.
R. D. Robertson, irrigation engineer, work in California.
S. H. Beckett, University of California, irrigation engineer, work in California.
Fred C. Scobey, irrigation engineer, in charge of work in Wyoming.
S. T. Harding, irrigation engineer, in charge of work in Montana and North Dakota.
H. W. Grunsky,[1] irrigation engineer, in charge of work in eastern Oregon.
F. W. Stanley, irrigation engineer, assistant in humid sections.
F. L. Peterson, irrigation engineer, in charge of work in Nevada.
H. C. Diesem, irrigation engineer, in charge of work in Nebraska and South Dakota.
H. E. Murdock, irrigation engineer, in charge of work in Kansas.
Paul A. Ewing, editor.

COLLABORATORS.

W. B. Gregory, Tulane University of Louisiana, in charge of investigations of pumping plants and canal systems for rice irrigation in the Gulf States.
V. M. Cone, Colorado Agricultural Experiment Station, in charge of work in Colorado.
F. L. Bixby, New Mexico Agricultural College, in charge of work in New Mexico.

IRRIGATION FARMERS.

John H. Gordon, R. G. Hemphill, R. E. Mahoney, and John Krall, jr.

[1] On furlough.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., November 20, 1912.

Sir: I have the honor to transmit herewith a report on the Irrigation Resources of California and Their Utilization, prepared by Frank Adams, under the direction of Dr. Samuel Fortier, chief of irrigation investigations of this office. This report is a summary of reports prepared in cooperation with the Conservation Commission of the State of California, as follows:

Irrigation resources of northern California, by Frank Adams.

Irrigation resources of central California, by S. T. Harding and R. D. Robertson.

Irrigation resources of southern California, by C. E. Tait.

Field reports on—

Use of water for irrigation in Shasta Valley in 1912, by N. M. Stover.

Use of water for irrigation from Feather River in 1912, by R. V. Meikle.

Use of water for irrigation from east side tributaries of San Joaquin River in 1912, by J. T. Kingdon.

Use of water for irrigation from San Joaquin River in 1912, by Harry Barnes.

Use of water for irrigation in Santa Clara Valley in 1912, by R. L. Egenhof.

Use of water for irrigation from Santa Clara River in 1912, by J. N. Irving.

Use of water for irrigation in the valley of Santa Ana River in 1912, by A. J. Salisbury, jr.

In addition to those whose names are attached to the above reports the following field agents assisted in collecting data for them: E. W. Stanton, jr., Stephen C. Whipple, James C. Marr, and R. W. Broadie.

The three reports on the irrigation resources of California have been published by the Conservation Commission of California, and manuscript copies of the reports on the use of water in 1912 have been filed with the conservation commission for future reference.

The Conservation Commission of the State of California, composed of Hon. George C. Pardee, Mr. Francis Cuttle, and Mr. J. P. Baumgartner, was appointed in 1911 for the purpose of investigating the natural resources of California and of recommending legislation for their proper conservation, and the above reports have been prepared to assist them in their work. Since 1900 this office has been making investigations of the water-right situation in California as well as of the extent and character of irrigation development, and in 1910 an irrigation census of California was taken under a cooperative agreement between this office and the Bureau of the Census. Since 1903 the irrigation investigations in California have been carried on in cooperation with the State of California, first through the State board of examiners, and since 1909 through the department of State engineering, of which Hon. W. F. McClure, State engineer, is the executive head. Therefore, in addition to the special investigations made during the past year in cooperation with the State conservation commission, this report has for its basis a large amount of data collected under the direction of this office in cooperation with other agencies.

It is recommended that the report be published as a bulletin of this office.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

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INTRODUCTION.

In a series of three reports on the irrigation resources of California,[1] prepared under cooperative agreement between the Secretary of Agriculture and the Conservation Commission of the State of California, there were presented descriptions of the irrigable areas of California, together with discussions of the irrigation water supplies of each, statements of the present extent of irrigation development, and estimates of future irrigation possibilities. These reports have been published by the Conservation Commission of California, but it is intended that this bulletin shall summarize them and present in brief form the results of a second study made in cooperation with the conservation commission, having to do with the use of water in 1912 in typical localities of the State.

In undertaking a reconnoissance investigation of the many irrigable areas of California and of the water supplies available to them, supplemented by special studies of the use of water for irrigation in 1912 in typical localities, it was not expected to present reports that would either completely set forth irrigation conditions or give final estimates of future possibilities. It was rather hoped to make such a statement of conditions and such an estimate of possibilities as would give a more comprehensive understanding of the irrigation resources of the State and of their utilization under existing laws than could be obtained from data heretofore published.

While it has long been known that California contains a very large area of agricultural land for which water for irrigation is available, it has also been well known that California has given much less attention to administrative irrigation laws than have most of the other Western States. The long failure to enact administrative irrigation legislation has been due less to lack of knowledge as to what is needed than to an absence of appreciation on the part of the public generally as to the importance of irrigation and the consequent value of such legislative measures as will bring about the most economical development. Further, the more rapid irrigation development in southern

[1] Irrigation Resources of Northern California, by Frank Adams; Irrigation Resources of Central California, by S. T. Harding and R. D. Robertson; and Irrigation Resources of Southern California, by C. E. Tait.—Report of the Conservation Commission of California, 1912.

California has led to a crystallization of ideas and practices there somewhat different from the ideas and practices that have grown up in the irrigated areas north of Tehachapi, resulting in an assumed diversity of interest between the northern and southern portions of the State. A third deterrent has been the adverse influence of those so situated as to be satisfied to let development under irrigation take its course without legislative guide or restriction.

California has long been a field of scientific agricultural investigation, so that the main agricultural characteristics of the State are well known. In 1880 Mr. Wm. Ham. Hall, State engineer, issued as part of his first report a report on the irrigation of the plains, in which questions of both land and water were treated exhaustively in the light of physical data and knowledge of irrigation then available.[1] Annual and special reports of the California Agricultural Experiment Station have considered questions of soils, alkalis, crops, waters, and culture methods from the standpoint of irrigation development. In 1883 Dr. E. W. Hilgard, until recent years director of the station, submitted to the superintendent of the census a treatise on the agricultural features of California, with an agricultural map, that outlined the various agricultural zones of the State and described both their physicogeographical and main soil features.[2] For many years the United States Geological Survey has been mapping topography, measuring streams, and studying underground waters in California, and for several years the United States Reclamation Service had engineers in the field looking for possibilities for development under the reclamation act. Since 1900 the Office of Experiment Stations has been prosecuting irrigation investigations in California, since 1903 in cooperation with the State, and bulletins giving results of these investigations have been published from time to time.[3] In addition, during 1910 and 1911, the Office of Experiment Stations directed a full irrigation census of California under cooperative agreement with the Bureau of the Census, this census covering not only acreages and costs, but also the more general features of irrigation development. Thus the investigation into irrigation resources with which this report deals had as a starting point a large mass of known data without which the work would not have been possible within the limits of time and money available under the agreement with the conservation commission. Even with these data, however, it has not been possible, in the short time available for the preparation of the reports of which this bulletin is a summary, to make more than a general reconnoissance investigation.

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[1] Report of the State engineer to the Legislature of California, session of 1880.

[2] U. S. Dept. Int., Census Office, Report on the Physical and Agricultural Features of the State of California, by E. W. Hilgard, Ph. D., 1884.

[3] See chiefly U. S. Dept. Agr., Office Expt. Stas. Buls. 100, 119, 133, 158, 207, 236, 237, 239; S. Doc. 246, 60th Cong., 1st sess.

IRRIGATION RESOURCES.

Irrigation is neither equally necessary nor equally advantageous throughout California, nor is it possible to determine either its necessity or its advantage wholly by the amount of the annual rainfall. If grain were the only crop grown but little irrigation would be expected in the coastal valleys of the northern half of the State, nor in some of the interior valleys north of Sacramento and Stockton. From Sacramento and Stockton southward, however, the degree of irrigation necessity would increase, becoming absolute in lower San Joaquin Valley, and in most of the State south of Tehachapi. But if it were not that, excepting in the mountain valleys, the California winter is a growing period, even the northern third of the State would not grow large annual crops without irrigation, because the rainfall in California comes mostly from November to April, followed by the well-known California rainless summer, during which few plants can be both germinated and brought to maturity without moisture artificially applied. It is the rainless summers that render irrigation either a necessity or a marked advantage in nearly every section of the State, and which make it advisable to consider every section in a State-wide irrigation study.

Because the agricultural features of California cover such a wide range, the most practicable way of treating the irrigation resources of the State is, first, by considering northern, central, and southern California separately (See Pls. I, II, and III), and, second, by following what might be termed irrigation zones, within which irrigation conditions and needs are similar.

NORTHERN CALIFORNIA.

For the purpose of this study northern California is taken to be that portion of the State north of San Francisco, San Pablo, and Suisun Bays, and north of the southern boundaries of Sacramento and Amador Counties. This area is readily divided into six irrigation zones. The following table lists these zones and summarizes the agricultural and the irrigated areas in each of them.

Summary of agricultural and irrigated areas in northern California.

Division.	Valley agricultural land.	Valley plains.	Foothill agricultural land.	Areas irrigated.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Northern coastal counties	502,200	.....	.....	2,675
North-central mountain valleys	435,000	.....	.....	103,850
Northeastern plateaus and valleys	867,000	.....	.....	161,930
Feather River valleys	158,000	.....	.....	50,600
Sierra foothills	.....	.....	789,000	45,250
Sacramento Valley	2,659,000	790,000	.....	123,500
Total	4,621,200	790,000	789,000	487,805

NORTHERN COASTAL COUNTIES.

The seven counties embraced within this division or zone (Pl. IV, fig. 1) have been generally considered as not requiring irrigation. For the extreme northern coast, as above Cape Mendocino, such is undoubtedly the case, as it is also for the remainder of the division if absolute necessity is meant, or if the crops grown are perennial and deep rooting, but away from the coast rainless summers are as much a fact here as elsewhere in the State, and for such crops as alfalfa and summer-growing annuals irrigation grades from a distinct advantage to almost a necessity. The growth and yield of even orchards and vineyards when on shallow and nonretentive soil can also undoubtedly be increased by irrigation water where the topography and supply permit its application. It can safely be predicted that throughout this entire division, excepting along the immediate coast, every drop of water that can be put onto land will eventually be used in irrigation.

Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin.

Area.	County.	Valley agricultural land.	Area irrigated.	Principal water sources for irrigation.[1]
		Acres.	*Acres.*	
Smith River Valley and adjacent coastal lands.	Del Norte	36,000	0	Smith River; supply ample.[1]
Lower Klamath River	do	8,000	0	Klamath River; supply ample.[1]
Upper Klamath and tributaries.	Humboldt	300	100	Klamath River and tributaries; supply ample.
Prairie Creek	do	700		Prairie Creek; supply ample.[1]
Orick	do	1,300		Redwood Creek; supply ample.[1]
Big, Stone, and Freshwater Lagoons.	do	1,800		Lagoons south of Orick; supply ample.[1]
Hupa Valley	do	6,800	150	Trinity River; supply ample.
Little River	do	2,400		Little River; supply ample.[1]
Essex	do	700		Mad River; supply ample.[1]
Upper Mad River, scattering.	do	1,000		Mad River and tributaries; supply ample.
Mad River bottoms	do	6,200		Mad River; supply ample.[1]
Arcata bottoms	do	11,500	0	Mad River and Jacoby and Freshwater Creeks; supply ample.[1]
Lower Humboldt Bay drainage.	do	5,900	0	Elk River and Salmon Creeks; supply ample.[1]
Kneeland Prairie	do	9,500	0	None readily accessible.
Maple Creek	do	600	0	Maple Creek; supply ample.[1]
Eel River Valley	do	42,000	0	Eel River; supply ample.[1]
Elinor	do	500	0	Eel River and small tributaries; supply ample, mainly by pumping.[1]
Pepperwood	do	800	0	Do.
Shively	do	600		Do.
Englewood	do	300		Do.
Myers	do	300		South Fork Eel River; supply ample by pumping.
Miranda	do	300	50	Do.
Phillipsville	do	300		Do.
Fort Seward	do	600		Do.
Garverville	do	1,300		Do.
Van Duzen River, scattering.	do	2,500	25	Van Duzen River; supply ample.
Capetown	do	1,900	0	Bear River; supply ample.[1]
Petrolia	do	800	35	Mattole River and tributaries; supply ample.[1]
Upper Mattole Valley	do	4,300	0	Mattole River and tributaries; supply ample if storage is feasible.
Humboldt County, scattering.	do		6	
Long Valley	Mendocino	4,400	60	Long Valley Creek; supply ample if storage is feasible.

[1] Little irrigation likely; see text.

IRRIGATION MAP OF NORTHERN CALIFORNIA

U.S. DEPT. OF AGRICULTURE - OFFICE OF EXPERIMENT STATIONS
IRRIGATION INVESTIGATIONS

TO ACCOMPANY REPORT ON THE
IRRIGATION RESOURCES OF NORTHERN CALIFORNIA

Scale of Miles
4 0 4 8 12 16 20

· 1912 ·

PREPARED IN COOPERATION WITH THE
CONSERVATION COMMISSION OF CALIFORNIA

— LEGEND —

- Valley Agricultural Areas
- Plains in Sacramento Valley
- Foothill Agricultural Areas
- Irrigated Areas
- Principal Irrigation Canals
- Boundaries U. S. Reclamation Service Projects

NOTE This Map is not intended to show the Broken or Rolling Arable Areas in the Coast Range Mountains or to indicate with exactness the Boundaries of the different classes of Agricultural Land.

Base Sheet by U.S. Land Office Maps.

Wm. M. Humans Del.

Longitude West 123° from Greenwich

PHOTO-LITH. BRITTON & REY, LITHOGRAPHERS S.F.

— LEGEND —

- Valley Agricultural Areas
- Plains in San Joaquin Valley
- Foothill Agricultural Areas
- Irrigated Areas
- Principal Irrigation Canals
- Boundaries of Irrigation Districts

NOTE. This Map is not intended to show the Broken or Rolling Arable Areas in the Coast Range Mountains or to indicate with exactness the Boundaries of the different classes of Agricultural Land.

U.S. DEPT. OF AGRICULTURE - OFFICE OF EXPERIMENT STATIONS
IRRIGATION INVESTIGATIONS

IRRIGATION MAP
— OF —
CENTRAL CALIFORNIA

TO ACCOMPANY REPORT ON THE
IRRIGATION RESOURCES OF CENTRAL CALIFORNIA

Scale of Miles

· 1912 ·

PREPARED IN COOPERATION WITH THE
CONSERVATION COMMISSION OF CALIFORNIA

BASE: Chiefly U.S. Land Office Maps.

Longitude West 118° from Greenwich

Wm. M. Hamilton Del.

U.S. DEPT. OF AGRICULTURE - OFFICE OF EXPERIMENT STATIONS
IRRIGATION INVESTIGATIONS

IRRIGATION MAP
— OF —
SOUTHERN CALIFORNIA

TO ACCOMPANY REPORT ON THE
IRRIGATION RESOURCES OF SOUTHERN CALIFORNIA

Scale of Miles
0 5 10 20

· 1912 ·

PREPARED IN COOPERATION WITH THE
CONSERVATION COMMISSION OF CALIFORNIA

— LEGEND —

Agricultural Areas
Irrigated Areas
Principal Irrigation Canals
Boundaries of Irrigation Districts
Boundaries U.S. Reclamation Service Projects

NOTE This Map is not intended to show the Broken or Rolling Arable Areas in the Coast Range Mountains, or to indicate with exactness the Boundaries of the different classes of Agricultural Land.

SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SAN DIEGO
KERN
INYO
SAN BERNARDINO
RIVERSIDE
IMPERIAL

SANTA BARBARA CHANNEL
SAN PEDRO CHANNEL
OLD SANTA BARBARA CHANNEL
PACIFIC OCEAN

SAN MIGUEL I.
SANTA ROSA I.
SANTA CRUZ I.
SANTA BARBARA I.
SANTA CATALINA I.
SAN NICOLAS I.
SAN CLEMENTE I.

Longitude West 117 from Greenwich

Wm. M. Hanscom Del.

PHOTO-LITH. BRITTON & REY, LITHOGRAPHERS, S.F.

Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin—Continued.

Area.	County.	Valley agricultural land.	Area irrigated.	Principal water sources for irrigation.
		Acres.	*Acres.*	
Round Valley	Mendocino	18,400	20	Middle Fork Eel River and underground; supply ample; some drainage necessary.
Williams Valley	do	1,000	0	Run-off from all square miles of tributary watershed.
Willits Valley	do	8,000	10	Small creeks and probably underground-supply probably ample; much drainage needed.
Walker Valley	do	1,500	60	Walker Valley Creek and springs; run-off with storage probably ample.
Potter Valley	do	7,000	100	70 square miles of watershed on East Fork of Russian River; tunnel diversion from South Eel River and pumping; supply ample.
Redwood Valley	do	4,000	10	80 square miles of watershed on West Fork of Russian River and probably underground; supply present for at least considerable area.
Coyote Valley	do	3,800	10	80 square miles of watershed on East Fork of Russian River, South Eel River, and pumping.
Ukiah Valley	do	15,000	160	250 sqnare miles of watershed on Russian River; tunnel diversion from South Eel River, and pumping; supply ample.
Sanel Valley	do	5,000	0	Russian River by pumping.
Anderson Valley	do	5,600	25	Pumping from Navarro River and tributaries.
Garcia River Valley	do	1,800	0	Garcia River.[1]
Mendocino County, scattering.	do	.....	92	
Russian River Valley	Sonoma	35,000	200	Russian River; tunnel diversion from South Eel River, and pumping; with full development supply ample for area likely to be irrigated.
Dry Creek Valley	do	8,000	20	100 square miles of watershed producing mostly torrential flow; some pumping.
Santa Rosa Valley	do	90,000	60	Santa Rosa, Mark West, and Petaluma Creeks are perennial, but give small summer flow; underground water available in some cases where needed.
Knights Valley	do	2,500	13	10 square miles of local watershed.
Los Guilicos Valley	do	16,000	15	50 square miles of watershed would give partial supply if storage is available.
Sonoma Valley	do	23,000	344	80 square miles of watershed with storage required; artesian flow near Sonoma; supply inadequate for full irrigation.
Gravelly Valley	Lake	500	5	Proposed reservoir site.
Upper Lake	do	6,200	0	Middle Creek with 67 square miles of watershed of typical coast range topography above Clear Lake; average annual run-off is 770 acre-feet per square mile.
Bachelor Valley	do	1,900	0	13 square miles of local watershed.
West Lake Valley	do	1,100	0	Small local drainage and pumping from Clear Lake.
Scotts Valley	do	4,200	25	77 square miles of watershed; some artesian supply.
Big Valley	do	11,000	280	Kelsey Creek with 120 square miles of rough drainage yielding a large torrential run-off; reservoir reported privately surveyed with capacity of 27,500 acre-feet; supply should be ample if all conserved.
Long Valley	do	2,600	0	Long Valley Creek with about 40 square miles of watershed.
Little Indian Valley	do	1,400	24	North Fork of Cache Creek; Little Indian Valley on this stream has been considered as a reservoir site, the United States Reclamation Service estimating that 110 square miles of watershed will produce 50,000 acre-feet annually.[2]
High Valley	do	2,000	0	8 square miles of local watershed.
Burns Valley	do	900	0	Possibly minor storage and pumping from Clear Lake.
Lower Lake	do	1,700	31	9 square miles of local watershed and pumping from Clear Lake.

[1] Little irrigation likely; see text.

[2] U. S. Reclamation Service, Fifth Annual Report.

Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin—Continued.

Area.	County.	Valley agricultural land.	Area irrigated.	Principal water sources for irrigation.
		Acres.	*Acres.*	
Morgan Lake	Lake	1,700	0	10 square miles of local watershed; insufficient without underground supply.
Cobb Valley	do	400	50	10 square miles of local watershed on upper Kelsey Creek.
Coyote Valley	do	4,800	65	Putah Creek; supply ample if available; United States Reclamation Service estimates 80,000 acre-feet available for storage.[1]
Middletown	do	6,600	142	Putah Creek drainage; supply ample if available, although storage necessary.
Napa Valley	Napa	42,800	311	Napa River and Conn, Sarco, Milliken, Dry, and White Sulphur Creeks would give all needed with storage; tributary watershed of 235 square miles with light summer flow; underground supply uncertain.
Berryessa Valley	do	10,000	130	550 square miles of Putah Creek drainage with storage would supply water needed if legally available.
Capell Valley	do	700	0	16 square miles of local watershed on Capell Creek.
Foss Valley	do	400	0	10 square miles of local watershed.
Wooden Valley	do	1,100	0	8 square miles of local storage tributary to Suisun Creek.
Gordon Valley	do	1,000	0	18 square miles of local watershed.
Marin County, scattering	Marin	.....	67	
Total	.....	502,200	2,675	

[1] U. S. Reclamation Service, Fifth Annual Report.

As shown above, there is a total of 502,200 acres of valley agricultural land reported in the northern coastal counties, of which but 2,675 acres are reported irrigated. The normal annual precipitation in these counties ranges from 25 to 90 inches, and as a whole there is far more water available than can ever be utilized. Eliminating Del Norte County and the immediate coast areas of Humboldt, Mendocino, Sonoma, and Marin Counties, the area of irrigable agricultural land is substantially 380,000 acres. Probably not over 100,000 acres will ever be watered.

In this division the water supply is largest where the agricultural areas are smallest and the need of irrigation is least. For instance, Klamath River, which passes for a number of miles through northern Humboldt County, carries a mean annual flow at Keno, Oreg., many miles above, of 1,690,000 acre-feet,[1] but only 8,300 acres of agricultural land were found along it in this division, with little irrigation likely even on that. A similar situation in the matter of excess supply and small need for irrigation exists along the other large north-coast streams, namely, Smith River, in Del Norte County, and Mad and the main Eel Rivers, in Humboldt County. The water supply is likewise ample for all needed or beneficial use along the smaller streams of Humboldt County, including principally Redwood Creek and Van Duzen, Mattole, and South Fork of Eel Rivers. Because

[1] U. S. Geol. Survey Water-Supply Paper No. 300.

of the absence of agricultural land, or due to humid conditions, very little, if any, irrigation is needed along the immediate coast of Mendocino, Sonoma, and Marin Counties, although Ten Mile, Noyo, Albion, Navarro, Garcia, Russian, and other rivers carry relatively large quantities of water into the Pacific. In parts of the interior of these and of Lake and Napa Counties irrigation would be beneficial in excess of that which will be possible by direct diversion of surface streams, although in all cases the annual precipitation of watersheds adjacent to the agricultural areas would supply all needed irrigation water if it could be stored. In other cases, pumping from underground waters or from lakes would give what is needed. The largest supply for irrigation in this division would come from South Fork of Eel River and its branches and from Russian River, because the largest areas of agricultural land that can be benefited by irrigation are within reach of these streams.

NORTH-CENTRAL MOUNTAIN VALLEYS.

That portion of California between the northern end of Sacramento Valley and the Oregon line, and extending from the lava plateaus of Modoc and Lassen Counties on the east to the coast counties of Humboldt and Del Norte on the west, comprises what is conveniently classified as the north-central mountainous division of the State. Within this division are the counties of Siskiyou and Trinity, Shasta County above the junction of the Sacramento with the Pit, and a small portion of Lassen County, included in Fall River Valley about Pittville (Pl. IV, fig. 2). The northern half of the division, comprising Siskiyou County, and extending from Mount Shasta and Scott and Trinity Mountains to Oregon, is within the Klamath drainage. Trinity County is almost wholly within the drainage of Trinity River, which in turn empties into the Klamath in northern Humboldt.

Speaking generally, this division is an intermountain region of relatively backward irrigation development. While scattered over four counties, the agricultural areas are mainly similar in conditions. They range in elevation from 2,000 to 4,000 feet, generally have a rainfall of less than 20 inches, are surrounded by forest or mining interests, and are devoted mainly to crops associated with stock raising. The valleys, although already generally prosperous, are capable of a considerable advancement, but this must be conditioned on a more modern irrigation system and a less wasteful irrigation practice. While the need of irrigation is generally recognized and most of the water in immediate proximity to the irrigable land is claimed and supposedly put to use, yet that use is far less economical than would be required under a public irrigation policy that would look to the most complete utilization possible.

Summary of agricultural and irrigated areas in north-central mountain valleys.

Area.	County or counties.	Valley agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Lower Klamath Lake	Siskiyou	23,000	4,600
Butte Valley	do	65,000	2,800
Klamath River, above Salmon River	do	23,000	8,900
Shasta Valley	do	158,000	23,800
Scott Valley	do	55,500	15,500
Fall River Valley	Shasta and Lassen	66,000	24,700
Salmon River and tributaries	Siskiyou	600	600
Red Rock Valley	do	11,000	0
Grass Lake	do	4,400	0
Sisson Valley	do	2,200	1,400
Burney and Goose Valleys	Shasta	6,000	5,000
Cayton Valley	do	1,700	1,300
Hat Creek	do	4,500	3,000
Hay Fork, and scattering	Trinity	8,000	6,355
Pit River and tributaries, from McCloud River to Burney Creek.	Shasta	1,700	1,700
Sacramento River, above Pit River	do	500	328
McCloud River, scattering	do	900	900
Scattering		3,000	2,967
Total		435,000	103,850

The absence of stream gaugings in this division makes it necessary to use general figures in estimating the water supply at hand for irrigation. The largest agricultural areas are Shasta, Scott, Fall River, and Butte Valleys. For Shasta Valley numerous perennial springs aggregate in flow about 150 cubic feet per second and underground sources furnish the most dependable supply, with large quantities of water available for direct diversion from Shasta River and its numerous tributaries, in addition to the springs during spring and early summer. Klamath River has also been considered as available here, so that with some storage, likely feasible on some of the Shasta River tributaries, water may be considered available for a very much larger area than the 23,800 acres now irrigated.

In Scott Valley water is considered at hand, if storage is feasible, to water all of the 55,500 acres of agricultural land. In Fall River Valley there is a very large surplus, and in Butte Valley there is a deficiency, except as underground waters may be developed. In the other areas the water supply varies from none to a sufficiency or excess.

The summary above shows 435,000 acres of valley agricultural land in the north-central mountain valleys, of which 103,850 acres are irrigated. If present use were to continue, there would be little opportunity outside of Fall River Valley and along the Klamath for increasing the irrigated area from supplies now at hand, but with better use the present irrigated area should be nearly doubled without much storage or without carrying supplies from relatively distant sources. With such storage and long-distance conveyance as is found economical, it is believed that the irrigated area in these

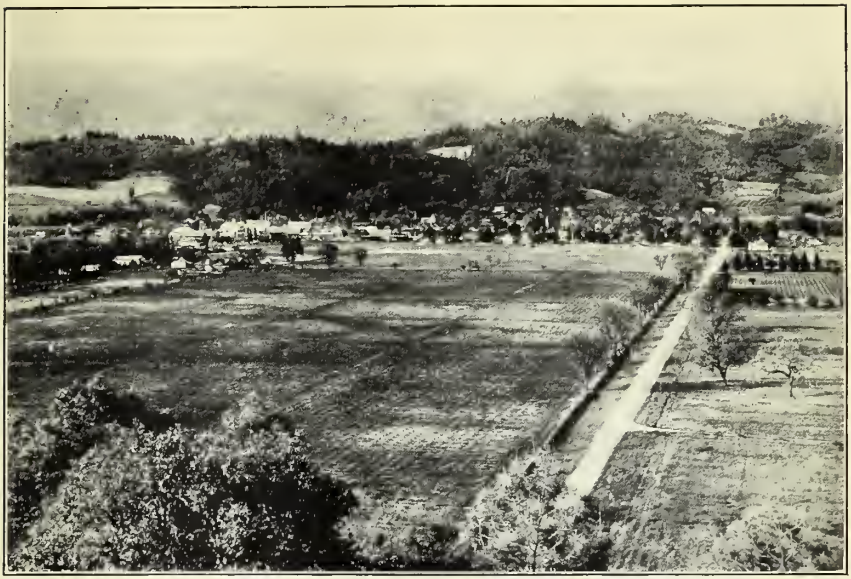


FIG. 1.—SECTION OF NAPA VALLEY, NORTHERN COASTAL COUNTIES.

FIG. 2.—IRRIGABLE LAND ALONG FALL RIVER IN FALL RIVER VALLEY, NOW DRY FARMED, NORTH-CENTRAL MOUNTAIN VALLEYS.

FIG. 1.—IRRIGABLE VALLEY LANDS SOUTH OF RED BLUFF, SACRAMENTO VALLEY, NOW DRY FARMED.

FIG. 2.—LANDS IN SACRAMENTO VALLEY, SIMILAR TO LANDS SHOWN IN FIG. 1, AFTER IRRIGATION.

north-central mountain valleys will eventually reach 225,000 to 250,000 acres, or more than one-half of the valley agricultural land found.

NORTHEASTERN PLATEAUS AND VALLEYS.

Most of this division or irrigation zone is in the Great Basin drainage and it is all within Modoc and Lassen Counties, ranging in elevation from 4,000 to 5,000 feet, with normal rainfall on the agricultural areas usually from 14 to 22 inches. Although some hardy fruits are grown in favored valleys, the agricultural practice is essentially that of the live-stock industry.

Summary of valley agricultural and irrigated areas in northeastern lava plateau region, in Modoc and Lassen Counties.

Area.	County or counties.	Agricultural land.	Area irrigated.
		Acres.	*Acres.*
Surprise Valley	Modoc	113,000	35,200
Goose Lake Valley	do	39,000	5,800
Fandango Creek	do	1,300	200
North Fork Pit River	do	2,300	2,300
Alturas and South Fork Pit River	do	40,000	18,600
Rattlesnake Creek	do	8,000	0
Lost River Drainage	do	47,000	2,900
Fairchild Meadow and Antelope Plains	do	25,000	1,300
Ingalls Valley	do	700	0
Warm Spring Valley	do	32,000	2,050
Black Canyon	do	1,200	500
Stone Coal Valley	do	1,000	500
Round Valley	do	6,000	1,200
Big Valley	Modoc and Lassen	83,000	14,500
Ash Creek Valley	Lassen	6,500	4,000
West Valley	Modoc and Lassen	1,200	1,200
Jess Valley	Modoc	4,500	3,400
Little Valley	Modoc and Lassen	900	900
Dixie Valley	do	2,900	1,200
Madeline Plains	Lassen	153,000	3,900
Dry Valley	do	3,000	0
Grasshopper Valley	do	6,300	1,900
Painters Flat	do	2,000	0
Snake and Rush Creeks	do	4,700	600
Secret Valley	do	19,000	1,280
Bull Creek	do	2,700	0
Horse Lake	do	5,400	2,600
Eagle Lake	do	1,700	200
Willow Creek	do	13,900	7,100
Susan River	do	66,000	22,300
Honey Lake Valley	do	154,000	12,200
Long Valley	do	9,300	4,100
Scattering, unlocated		10,500	10,000
Total		867,000	161,930

More stream-flow records are accessible for this division than for the two just mentioned. When Big Valley was considered as a reservoir site by the United States Reclamation Service it was estimated that about 1,000,000 acre-feet of water would annually be available from Pit River watershed above that site,[1] but this is in excess of the quantity that can be considered available in the sense that it can be used in this division. Counting all agricultural areas along Pit

[1] U. S. Reclamation Service, Fifth Annual Report.

River and its tributaries reasonably within reach of water down to and including Big Valley, 163,300 acres are found, after eliminating West and Jess Valleys, as probable reservoirs. For this acreage 500,000 acre-feet of water should be sufficient. For the Great Basin portion of this division, including Surprise and Honey Lake Valleys and Madeline Plains, 400,000 acre-feet is estimated as the total water crop that might be utilized. But considering existing conditions of land and water and that Big and Round Valleys may ultimately be used for storage, doubling the present irrigated area of 161,930 acres, this is taken as the probable limits of future development. Utilizing Big and Round Valleys as reservoirs for Sacramento Valley irrigation would reduce the possible irrigation in this division by about 50,000 acres.

FEATHER RIVER VALLEYS.

These valleys are mostly in Plumas and Sierra Counties, on the tributaries of Feather River, at elevations of 3,400 to 5,800 feet. Irrigation here is almost entirely that of the mountain meadow, with normal annual precipitation in the surrounding mountains of about 40 to 90 inches. The water supplies within this division are greatly in excess of local needs. Some of the valleys in this division are sure eventually to be used for reservoirs for power and irrigation purposes below, Big Meadows already being so utilized.

Summary of valley agricultural and irrigated areas in the high mountain valleys in Plumas, Sierra, and southwestern Lassen Counties.

Area.	County or counties.	Valley agricultural land.	Area irrigated.
		Acres.	*Acres.*
Sierra Valley	Sierra and Plumas	101,000	23,900
Mountain Meadows	Lassen	13,000	400
Big Meadows	Plumas	.....	[1] 1,000
Indian Valley	do	11,000	5,900
Genesee Valley	do	3,100	2,900
Meadow and Spanish Ranch Valleys	do	2,250	500
American Valley	do	4,300	4,000
Long and Mohawk Valleys	do	1,400	550
Red Clover Valley	do	4,250	2,100
Grizzly Valley	do	8,200	100
Scattering	do	9,500	9,250
Total	.....	158,000	50,600

[1] Big Meadows reservoir will submerge most of this area when completed.

The stream-flow records show with some definiteness the quantity of water in Feather River valleys. The mean annual flow of Feather River at Oroville is about 6,000,000 acre-feet,[1] with 1,649,385 acre-feet estimated as annually available above known storage sites.[2]

[1] U. S. Geol. Survey Water Supply Paper No. 298. [2] U. S. Reclamation Service, Fifth Annual Report.

But only a small portion of this is needed or can be used in the upper areas termed the Feather River valleys, the total valley agricultural land there aggregating only 158,000 acres, and only about 140,000 acres after eliminating one area of excessive elevation. Sierra Valley in this division has a large area and agriculture there is likely to attain considerable development, but in the other valleys, of which American Valley, above Quincy, with 13,000 acres, is the largest, it does not seem likely that the character of agriculture will materially change owing to the local demand for forage, the relative inaccessibility of most of the areas, and the fixed tastes and customs of the people living in them.

Eliminating Grizzly Valley, because of its high elevation, the valley agricultural areas in this division become 149,800 acres. If none of the valleys in the division were to be utilized as reservoir sites, it is likely that the present irrigated area eventually would be more than doubled.

NORTHERN SIERRA FOOTHILLS.

The division classified as northern Sierra foothills lies above the Sacramento Valley plains and generally below an elevation of 2,500 feet. The agricultural areas in this belt are not continuous, nor is their total area easily defined or limited. The water sources for irrigation are both local streams and the larger east-side tributaries of Sacramento River. The irrigated crops are usually mainly deciduous and citrus fruits.

Summary of agricultural and irrigated areas in northern Sierra foothills.

Area.	County or counties.	Agricultural land.	Area irrigated.
		Acres.	*Acres.*
North of Feather River:			
Whitmore	Tehama and Butte	24,000	10,262
Paradise Ridge	Butte	12,000	700
Between Feather and Ynba Rivers:			
Wyandotte-Bangor	Butte and Yuba	38,000	1,395
Browns Valley	Yuba	25,000	1,750
Between Yuba and Bear Rivers: Nevada City-Smartville.	Yuba and Nevada	117,000	4,013
Between Bear and American Rivers:			
Placer County fruit districts	Placer	104,000	14,000
Orange Vale-Fair Oaks	Sacramento	29,000	4,450
Between American and Cosumnes Rivers:			
Georgetown	El Dorado	42,000	1,546
Placerville	do	26,000	1,613
Folsom-Pleasant Valley	El Dorado and Sacramento	148,000	1,100
South of Cosumnes River: Ione-Jackson	Sacramento and Amador	220,000	630
Scattering, unlocated		4,000	3,791
Total		789,000	45,250

Although stream-flow records are available for the larger streams passing through this division, uncertainties as to the place or the character of the future use of those streams make it impossible to attempt a definite estimate of the water supply that can be called available for irrigation. The topographically irrigable area is estimated as 789,000 acres, with 45,250 acres now reported irrigated. Owing to the roughness and inaccessibility of much of the Sierra region, some land that is irrigable in the sense that it is similar to land there now being irrigated has undoubtedly been overlooked and likewise probably some has been included as irrigable that should have been omitted. In nearly every section the annual water supply exceeds requirements, but difficulties of diversion, uncertainties as to storage, and adverse power and mining interests, and irrigation rights to Sacramento Valley hold back irrigation. No more than reasonable difficulties and complications, however, seem in the way of future irrigation increase to between 150,000 and 200,000 acres.

SACRAMENTO VALLEY.

This division of northern California is taken to include Sacramento Valley proper from Red Bluff to Collinsville, including both valley floor and adjacent valley plains; the broken areas about Redding and along the upper Sacramento, and the rolling agricultural foothills or upper valley plains bordering the west side of Sacramento Valley south of Cache Creek. (Pls. V, VI, and VII.)

Counting 535,000 acres on the east side and 424,500 acres on the west side now subject to temporary and intermittent overflow, the main Sacramento Valley floor scales to 2,633,000 acres. As classified and mapped according to the best available standards, the plains on the east side scale to 346,700 acres and on the west side to 326,300 acres. Adding 117,000 acres classified as Sacramento Valley plains north of Red Bluff gives a total area for Sacramento Valley of 3,449,000 acres.

The summary below shows the various areas of Sacramento Valley as they have been segregated according to county, river, or assumed arbitrary boundaries, together with the areas of agricultural and irrigated land reported. The irrigated areas given are those reported by the irrigation census taken in 1910 and revised for all of the larger areas to the season of 1912, inclusive.

Summary of agricultural and irrigated areas in Sacramento Valley.

Area.	County or counties.	Valley agricultural land.	Plains agricultural land.	Area irrigated.
		Acres.	*Acres.*	*Acres.*
Redding	Shasta and Tehama.	24,000	55,000	4,080
Happy Valley	do		62,000	1,628
West side:				
Red Bluff-Corning	Tehama	87,000	137,000	4,500
Orland	Glenn	79,000	32,300	5,300
Stoney Creek	do	3,000		2,250
Willows	do	186,000	40,000	6,000
Colusa	Colusa	330,000	39,000	7,875
Woodland	Yolo	400,000	78,000	14,570
Capay Valley	do	10,000		160
Solano	Solano	157,000		2,527
Vaca Valley	do	7,000		50
Suisun	do	30,000		278
East side:				
Red Bluff-Vina	Tehama	34,500	29,000	9,600
Chico	Butte	138,000	15,200	800
Glenn-Colusa east side	Glenn and Colusa	82,500		
Feather River	Butte	266,000	86,000	17,190
Sutter Basin	Sutter	158,000		218
Yuba	Yuba	113,000	14,500	4,186
Sacramento-Lincoln	Sutter, Placer, and Sacramento.	246,000	94,000	225
Sacramento-Galt	Sacramento	236,000	108,000	13,000
Lower Sacramento River islands	do	72,000		28,272
Scattering, unlocated				791
Total		2,659,000	790,000	123,500

The mean annual flow of water into Sacramento Valley at Red Bluff has been estimated to be 10,400,000[1] acre-feet and the mean outflow at Collinsville to be 26,000,000 acre-feet.[2] Some of the tributaries entering Sacramento Valley below Red Bluff are of more importance in irrigation than the main Sacramento, because they are more easy of diversion to the irrigable lands. Stoney, Cache, and Putah Creeks, on the west side, carry a total annual mean of more than 1,750,000 acre-feet, with known possible storage on them approximating 544,000 acre-feet, counting full development of Clear Lake. Antelope, Mill, and Deer Creeks, and Feather, Yuba, Bear, American, and Cosumnes Rivers, on the east side, have a total annual mean in excess of 13,000,000 acre-feet,[1] with more than 2,000,000 acre-feet of known storage.[3] Feather River alone carries in average years enough water to cover all of the valley land in Sacramento Valley to a depth of over 2 feet. These extensive surface supplies do not take into consideration large supplies that now come, or that eventually will come, from underground sources.

To consider total surface water supplies as above does not, however, indicate the amounts that can be considered as available for irrigation, because minimum rather than mean years govern development, and because many considerations may prevent the use of the

[1] U. S. Geol. Survey Water Supply Paper No. 298.

[2] Physical Data and Statistics of California, Wm. Ham Hall, 1886.

[3] U. S. Reclamation Service, Fifth Annual Report.

surface supplies for irrigation.[1] The total mean flow of Sacramento River at Collinsville during the months of April to September, inclusive, approximates, according to the best available data, 16,000,000 acre-feet. Allowing 7,000 cubic feet per second during that period for navigation, this approximating the present low-water flow, leaves nearly 13,500,000 acre-feet as an approximation of the water supply of the valley during these months in mean years. Including 3,400,000 acre-feet of known possible storage[1] in the entire basin that could be carried over from winter in mean years, the total would approximate 17,000,000 acre-feet. This large supply will never, however, be available for irrigation and 7,500,000 acre-feet may safely be used as the largest figure whose consideration is justified, because it is all that will ever be needed. To furnish this quantity of water in the months of April, May, June, July, August, and September, with an assumed use per acre during these months of 0.2, 0.5, 0.7, 0.7, 0.55, and 0.35 acre-foot per acre, respectively, and also to allow a continuous flow for navigation of 7,000 cubic feet per second, storage would be required in minimum years slightly above the total known to be possible. As the total flow of the entire Sacramento River system is not equally distributed over the valley in accordance with the distribution of irrigable land, the total flow out of the valley at Collinsville does not conclusively indicate storage necessities above the different areas.

While, as listed in the above table, the Sacramento Valley and plains agricultural lands taken together aggregate a much larger area than has generally been included in Sacramento Valley, the total figure is believed to represent the area that can be considered topographically situated to receive water. While water may not be economically available to all of the area under present standards of use, it does not seem feasible to eliminate any of it as being plainly outside of the reach of water. One million acres, roughly, are within the upper line of permanent or temporary overflow, with 800,000 acres naturally covered by every considerable flood, but of which something more than 300,000 acres are already more or less protected by dikes. Assuming the ultimate protection of all of the present overflow lands, but eliminating an estimated 250,000 acres that will still remain in river and by-pass and other drainage channels after flood protection is accomplished, and further reducing the irrigable area on account of roads, towns, and other uncultivated patches, the irrigable area of the valley probably approximates 2,500,000 acres. It is believed that this area can be considered fit for irrigation and that water for irrigation is now or will be made available to it.

[1] U. S. Reclamation Service, Fifth Annual Report.

CENTRAL CALIFORNIA.

Four divisions were made of central California for studying the irrigation resources, these being indicated in the summary below which classifies the areas according to the character of agricultural land in them.

Summary of agricultural and irrigated areas in central California.

Division.	Valley agricultural land.	Valley plains.	Foothill agricultural land.	Areas irrigated.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Central coastal valley	887,000			82,000
San Joaquin Valley	6,530,000	1,046,000		1,728,975
Sierra foothills above San Joaquin Valley			730,000	10,620
Areas east of the Sierra Nevada	472,000			137,760
Total	7,889,000	1,046,000	730,000	1,959,355

CENTRAL COASTAL VALLEYS.

As noted above, the central coastal valleys cover a reported agricultural area of 887,000 acres, with 82,000 acres, or about 10 per cent, reported irrigated. The table below summarizes 27 areas by counties, and gives the total and the irrigated acreages in each.

Summary of agricultural and irrigated areas in central coastal valleys.

Area.	County or counties.	Agricultural land.	Irrigated land.
		Acres.	*Acres.*
San Ramon Valley	Contra Costa	6,000	10
Bay Shore-Richmond-Stege	do	50	50
Lafayette	do	1,250	
Pacheco-Concord-Martinez	do	17,500	20
Ygnacio Valley	do	11,800	
San Francisco	San Francisco	400	400
East Bay Shore	Alameda	59,500	2,290
Castro Valley	do	2,200	
Sunol Valley	do	2,500	
Livermore Valley	do	53,000	80
West Bay Shore	San Mateo	33,600	1,230
Pacific Shore	do	23,400	2,440
Santa Clara Valley	Santa Clara	148,000	42,550
Along coast, Santa Cruz to Davenport	Santa Cruz	4,300	
Along coast, Santa Cruz to Capitola	do	3,200	520
Pajaro Valley	do	26,000	670
Do	Monterey	6,000	700
Gilroy	Santa Clara	43,000	1,200
Paradise Valley	do	3,800	20
Hollister	San Benito	59,500	3,300
Lower Salinas Valley	Monterey	250,000	25,000
Upper Salinas Valley	Monterey and San Luis Obispo.	60,000	300
San Antonio Valley	Monterey	18,000	
Carmel Valley	do	6,500	
San Luis and Los Osos Valleys	San Luis Obispo	24,000	80
Chorro Valley	do	9,000	640
Arroyo Grande and Los Borros Valleys	do	12,000	500
Nipoma Valley	do	2,500	
Total		887,000	82,000

With the exception of Salinas River the streams of this division flow to the coast through short courses only, in consequence having but small watersheds, with none of them regularly, if at all, snow covered in winter. Underground waters now supply over one-third of the total irrigated area, and their use is increasing at a more rapid rate than is that of the surface streams. The most important irrigation streams are Alameda Creek, draining Livermore Valley and being nearly all under control for municipal uses; Coyote, Guadalupe, and Los Gatos Creeks, in Santa Clara Valley; Pajaro River, draining lower Santa Clara and San Benito County Valleys, the latter through its two main tributaries, Llagas Creek and San Benito River; Salinas River, draining Salinas Valley; and San Luis Obispo and Arroyo Grande Creeks, two small streams in San Luis Obispo County. In Livermore Valley irrigation could be beneficially practiced throughout its extent, but the water supply is controlled mostly for use in San Francisco. Some water is pumped and more would be pumped if adverse rights for municipal use did not interfere. If water is brought from the Sierra Nevada to the Bay cities, as contemplated, some water may be released for irrigation in this valley. At present, owing to lack of water for irrigation, the predominating crops are grains. In Santa Clara Valley much of the surface water is used in winter and spring irrigation, but a considerable quantity still goes to waste. Underground waters occur at varying lifts up to 100 feet and over in a few cases, and are extensively utilized. Artesian flow is plentiful between San Jose and San Francisco Bay, and now waters vegetables, alfalfa, and grasses to the extent of 7,000 acres.

The underground waters in Santa Clara Valley should be capable of further development, but no data are at hand for estimating to what extent. In Santa Cruz County the agricultural areas reported lie along the coast, where irrigation is not particularly needed, although practiced to a small degree. San Lorenzo River and numerous torrential creeks pass through these coast areas, but are not drawn on extensively for irrigation. The most important coastal area in the county is Pajaro Valley, lying partly across Pajaro River in Monterey County, the water sources here being Pajaro River and underground waters. In the Pajaro River drainage area above Pajaro Valley, namely, about Gilroy, in Santa Clara County, and about Hollister, and in San Juan Valley in San Benito County, the present use of surface water is much less than the annual run-off. Extensive use of this surplus water will require storage, of which none of consequence is known to be available. Underground water conditions are favorable in parts of the drainage, particularly near the streams, and some artesian flow is encountered. At various times much of the orchard land in Pajaro Valley was irrigated in connection

FIG. 1.—TYPICAL PLAINS ON THE EAST SIDE OF SACRAMENTO VALLEY.

FIG. 2.—TYPICAL HIGHER VALLEY LANDS SUSCEPTIBLE OF IRRIGATION IN SACRAMENTO VALLEY.

FIG. 1.—TYPICAL ROLLING PLAINS ON WEST SIDE OF SACRAMENTO VALLEY.

FIG. 2.—TYPICAL LOWER ROLLING FOOTHILLS NEAR FAIR OAKS AND ORANGE VALE, NORTHERN SIERRA FOOTHILLS.

FIG. 1.—TYPICAL PLAINS ON EAST SIDE OF SAN JOAQUIN VALLEY.

FIG. 2.—WHERE THE PLAINS BREAK TO THE LOWER SIERRA FOOTHILLS ABOVE SAN JOAQUIN VALLEY.

FIG. 1.—IRRIGATED LANDS IN THE NORTHERN SIERRA FOOTHILLS NEAR ROCKLIN.

FIG. 2.—IRRIGATED LANDS NEAR PORTERVILLE, SHOWING BREAK FROM VALLEY TO LOWER SIERRA FOOTHILLS ABOVE SAN JOAQUIN VALLEY.

FIG. 3.—IRRIGATED STRAWBERRIES IN NORTHERN SIERRA FOOTHILLS.

with intercropping of berries and in some cases of sugar beets, but with the maturing of orchards the irrigation has ceased, and it is not probable that irrigation will be extensively developed in this valley. In Salinas Valley, Salinas River is the main water source, carrying an estimated mean annual flow, including floods, approximating 500,000 acre-feet,[1] with about 200,000 acre-feet in minimum years. Being torrential, the surface supplies of Salinas River and tributaries can not be extensively used without storage. Over 100 pumping plants now draw water from the underground supplies in the valley, these supplies being capable of greatly increased development. Recently a promising artesian flow has been found in Salinas Valley about Paso Robles. In San Antonio Valley, east of Salinas Valley, but little water is available, yet in Carmel Valley, a typical coast area west of Salinas Valley, ample water is at hand with little of it needed or used. In San Luis, Osos, and Chorro Valleys water for irrigation is limited, although where sunk in old stream channels wells give sufficient water to irrigate small areas and small reservoirs are likely to be built to some extent to conserve surface supplies. Arroyo Grande Valley is supplied by Arroyo Grande Creek, and some extension would be possible through small storage and pumping from underground sources. Nipomo Valley is crossed by several small streams of torrential flow. In this small valley no irrigation is reported, but it should be possible to a limited extent.

In nearly all of the areas of the central coastal valleys listed above crops of high value can be grown under irrigation, and considerable expense will be justified for getting water. It seems not improbable that 200,000 acres will eventually be irrigated in these valleys, and if they were situated where irrigation was a necessity rather than merely an aid, the irrigated area would be sure to greatly exceed that figure.

SAN JOAQUIN VALLEY.

Including the east-side plains, San Joaquin Valley is the largest single arable area in California and contains also the largest area of irrigated land. On the west side the valley lands are continuous from the valley trough to the dry hills, but on the east side the difference between the lower and the somewhat higher lands next to the foothills has been noted, as in case of both west and east sides in Sacramento Valley, by classifying them as valley plains (Pl. VIII).

The table below summarizes the various unit areas of San Joaquin Valley as they have been segregated for investigation, noting their locations by counties and as to whether they lie north or south of the ridge below San Joaquin River that has been built up by Kings River, and that separates the valley into two main hydrographic divisions.

[1] U. S. Geol. Survey Water Supply Paper No. 300.

Summary of agricultural and irrigated areas in San Joaquin Valley.

Area.	County or counties.	Valley lands.		Plains land.	
		Total agricultural.	Area irrigated.	Total agricultural.	Area irrigated.
		Acres.	*Acres.*	*Acres.*	*Acres.*
Areas south of San Joaquin River:					
Southern Kern County	Kern	390,000	115,500	228,000	570
Wasco	do	368,000	32,500	81,000	.....
Lands along Buena Vista Slough.	do	116,000	40,000	.....	.....
Antelope Plains, west-side valley.	do	304,000	.....	.....	.....
White and Deer Creeks	Tulare	181,000	7,600	37,000	1,430
Portersville	do	162,000	38,010	37,500	11,710
Kaweah River	Tulare and Kings	342,000	117,550	37,000	7,130
Valley lands south and west of Tulare Lake.	do	240,000	58,420	.....	.....
Present area of Tulare Lake.	Kings	[1] 133,000	.....	.....	.....
Valley lands west of Tulare Lake.	do	119,000	.....	.....	.....
Alta	Fresno	147,000	93,960	39,000	1,130
Hanford	Kings	226,000	159,360	.....	.....
Fresno	Fresno	535,000	325,400	44,500	1,220
Murphy Slough	do	135,000	77,840	.....	.....
Jamesan	do	130,000	43,000	.....	.....
West side, north of Tulare Lake.	Fresno and Kings	763,000	4,580	.....	.....
Total		4,158,000	1,113,720	504,000	23,190
Areas north of San Joaquin River:					
West side, Firebaugh to Crows Landing.	Fresno, Merced, and Stanislaus.	367,000	127,250	.....	.....
West side, Crows Landing to Tracy.	Stanislaus and San Joaquin.	143,000	6,200	.....	.....
West side, Tracy to Bay Point.	San Joaquin and Contra Costa.	66,000	.....	.....	.....
Madera	Madera	390,000	43,000	112,000	40
Merced	Merced	361,000	[2] 84,895	112,000	([3])
Modesto–Turlock	Stanislaus and Merced	315,000	135,760	135,000	.....
South San Joaquin–Oakdale.	Stanislaus and San Joaquin.	129,000	4,000	110,000	.....
Stockton	San Joaquin	256,000	13,320	73,000	.....
San Joaquin delta lands	Contra Costa and San Joaquin.	315,000	177,600	.....	.....
Total		2,372,000	592,025	542,000	40
Grand total		6,530,000	1,705,745	1,046,000	23,230

[1] Not included in total.
[2] This figure includes the area holding water rights under Crocker-Huffman Canal, only 19,500 acres of which, according to the manager of the company, actually had water in 1912, 3,000 acres of this having been pasture land flooded during high water.
[3] Not segregated from valley irrigated areas.

The discharge of all of the main rivers of San Joaquin Valley is known with some definiteness,[1] but the limits of the underground sources, while large, can only be estimated. For the streams from San Joaquin River north the total mean annual discharge in minimum years has been 4,740 cubic feet per second, and that for the streams from Kings River south 2,060 cubic feet per second, the two totals being equivalent to a discharge of about 4,900,000 acre-feet. In average years the discharge has been approximately 12,000,000 acre-feet, or sufficient, if complete utilization were practicable, for 4,000,000 acres on a gross duty of 3 acre-feet per acre. Complete utilization, however, would require greater storage than is practicable, and even

[1] U. S. Geol. Survey Water Supply Paper No. 299.

after all practicable storage has been built use will still need to be adapted to variations in stream flow. Underground waters have already been developed for over 170,000 acres, and on the basis of preliminary studies by the Geological Survey [1] these supplies have been estimated to be capable of ultimate development to 5,000 cubic feet per second, or a total of about 1,800,000 acre-feet with continuous flow for six months, although this figure may be too high.

The above table shows a total valley and plains area of 7,576,000 acres topographically irrigable, with 1,728,975 acres irrigated. While, with the exception of parts of the west side, all of this large area is susceptible of irrigation from some source, its total extent exceeds the area for which water is at hand. The area in San Joaquin Valley that will ultimately be irrigated will depend upon many factors influencing the duty of water and is difficult to estimate. Increase in land values will require the highest economic development possible under irrigation. Estimating mainly from present standards, 1,650,000 acres out of a total of 4,662,000 acres from Kings River south, and 2,200,000 acres out of a total of 2,914,000 from San Joaquin River north, are considered as being irrigable from surface or underground sources, making a total of 3,850,000 acres, or a little less than 50 per cent of the whole. Some of the increased use of water that will come through both storage and development of underground waters will not increase the present irrigated acreage, the additional use in such cases being on land now irrigated in early summer but without water in the late season. Thus far but little storage has been built, irrigation having been adapted to the variations in stream flow. From Kings River south present use more nearly approaches economical development than from San Joaquin River north, averaging 1 acre irrigated for each 3.5 acre-feet of mean annual discharge of surface streams, and 1 acre irrigated for each 1.5 acre-feet of water in minimum years. The largest use in the southern portion of the valley is from Kings River with 628,780 acres irrigated, Kern River being second with 176,220 acres irrigated, Kaweah River third with 109,700 acres irrigated, and Tule River fourth with 47,775 acres irrigated. In the northern part of the valley largest use is made of San Joaquin River, with 116,500 acres of cropped land irrigated from the main stream above the delta, and 177,600 acres irrigated in the delta. This does not include 136,000 acres of pasture artificially flooded, and 73,000 acres of pasture naturally flooded in normal years. Counting only the cropped irrigated area, including those in the delta, 1 acre is now irrigated for each 6 acre-feet of water in mean years and for each 2.7 acre-feet in the minimum year of record. The Tuolumne, with the largest flow of any San Joaquin

[1] U. S. Geol. Survey Water Supply Paper No. 222.

stream and the largest known storage possibilities, now irrigates 135,320 acres, and is the only stream capable of watering all of the valley and plains immediately tributary to it. The third largest present use from San Joaquin River north is on Merced River. It is only on the west side that large continuous areas will be without water for irrigation.

SIERRA FOOTHILLS ABOVE SAN JOAQUIN VALLEY.

With the citrus areas east of Porterville, Lindsay, and Exeter, classed with the San Joaquin plains areas, the foothill areas above San Joaquin Valley are in the aggregate not now highly developed. So far irrigation has been confined to small miscellaneous family orchards, vegetable gardens, and some meadows and alfalfa (Pl. IX). Where transportation is near, fruit growing is successful with water available for irrigation. In the lower foothills, which merge into the upper valley plains, some grain is grown without irrigation, but here the lands are used chiefly for grazing, as they will in all probability mostly continue to be used. Any segregation of the arable areas in these foothills must necessarily be very rough. Between the valley plains and elevations up to 2,500 and 3,000 feet, 730,000 acres are classed as constituting the arable zone, distributed as listed in the following table:

Summary of agricultural land in Sierra foothills above San Joaquin Valley.

Area.	County or counties.	Foothill agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Between Mokelumne and Calaveras Rivers	San Joaquin	37,500	0
Do	Calaveras	54,500	560
Between Calaveras and Stanislaus Rivers:			
Lower foothills	San Joaquin, Stanislaus, and Calaveras.	115,000	40
Salt Springs Valley	Calaveras	47,000	100
Vicinity of Andreas and Angels Camp	do	15,000	570
Between Stanislaus and Tuolumne Rivers:			
Lower foothills	Stanislaus and Tuolumne	46,000	40
Vicinity of Sonora	Tuolumne	81,000	2,300
Between Tuolumne and Merced Rivers:			
Lower foothills	Stanislaus, Merced, Tuolumne, and Mariposa.	53,000	0
Vicinity of Coulterville	Tuolumne and Mariposa	22,000	230
Between Merced and San Joaquin Rivers:			
Upper Bear Creek drainage area	Merced and Mariposa	67,000	0
Upper Mariposa drainage area	Mariposa	62,000	0
Upper Chowchilla Creek drainage area	do	50,000	40
Upper Fresno River drainage area	do	27,000	200
Madera County areas	Madera	18,000	40
Upper Kern River Valleys	Kern	35,000	6,500
Total		730,000	10,620

Between Mokelumne and Calaveras Rivers in the above areas water now used for irrigation is obtained from Mokelumne River and tributaries. Between Stanislaus and Tuolumne Rivers the water

source now utilized for irrigation is South Fork of Stanislaus River, the irrigated lands being in the vicinities of Sonora, Columbia, Jamestown, Soulsbyville, and Tuolumne. Between Tuolumne and Merced Rivers the foothill areas are much broken and no irrigation development has taken place, except in a few scattered areas about Coulterville, local streams being utilized. Between Merced and San Joaquin Rivers the arable foothill areas are in irregular sloping plateaus, separated by the narrow valleys of Merced River and of Bear, Mariposa, and Chowchilla Creeks. Large-scale irrigation development is not likely, because water for irrigation will be dependent upon storage. For the upper Kern River valleys, which are the remaining foothill areas listed in the table, the source of supply is South Fork of Kern River.

Owing to the San Joaquin Valley agricultural areas being generally larger than there is water to cover, and further owing to the relative inaccessibility of the foothills above them, except along the few railroads to which there is local access, available data do not seem to warrant estimating future development under irrigation in these central California Sierra foothills in excess of 50,000 or 60,000 acres.

VALLEYS EAST OF THE SIERRA NEVADA.

Agricultural and irrigation conditions east of the crest of the Sierra Nevada are wholly different from those elsewhere in central California. The altitude of the agricultural areas varies from 3,700 to 7,000 feet and the normal rainfall varies from about 3 inches at Keeler to about 15 inches at Bodie. The predominating crops are forages and grains and the methods of irrigation are generally wasteful, being typical of all stock-raising sections. The following table lists the areas and gives their agricultural and irrigated areas:

Summary of agricultural and irrigated areas in the valleys east of the Sierra Nevada.

Area.	County or counties.	Agricultural land.	Area irrigated.
		Acres.	*Acres.*
Alpine County	Alpine	3,500	3,350
Antelope Valley	Mono	22,100	16,700
Bridgeport Valley	do	24,200	19,100
Area southwest of Mono Lake	do	19,000	2,720
Area north of Mono Lake	do	63,000	1,360
Owens River areas:			
Adobe Meadows	do	27,000	0
Valley north of Bishop	Mono and Inyo	77,000	260
Long Valley	Mono	21,500	18,700
Round Valley	Inyo	8,700	5,630
Owens Valley, Bishop to Aberdeen	do	100,000	47,400
Owens Valley, Aberdeen to Owens Lake	do	98,000	21,900
Owens Valley, west and south of Owens Lake	do	8,000	640
Total		472,000	137,760

In Alpine County and in Antelope and Bridgeport Valleys but small portions of the agricultural area are unirrigated and the water supplies are generally sufficient for the whole, coming from West and East Forks of Carson River for Alpine County, from West Walker River for Antelope Valley, and from East Walker River and Robinson, Buckeye, and Swager Creeks for Bridgeport Valley. For the areas southwest of Mono Lake, Rush and Leevining Creeks furnish the irrigation water, and for the areas north of Mono Lake the supply comes from Mill and Wilson Creeks, all of these being small mountain streams. Estimated evaporation from Mono Lake, which receives much of its annual supply from Rush and Leevining Creeks, indicates ample water for all of the agricultural area if storage is feasible, but due to the prevailing high altitudes only such development is likely as is justified in connection with stock raising. A similar situation exists with reference to Mill Creek. The eastern part of the area is backed by an arid drainage and irrigation hardly seems economical.

The remaining areas in this division are in the general Owens River drainage basin. The water supply comes from the eastern slope of the Sierra Nevada through a north and south length of about 100 miles. The Los Angeles Aqueduct is being built for the diversion of 430 cubic feet per second from this drainage for use in and about Los Angeles. This system contemplates storage in Long Valley and in other reservoirs along the aqueduct line. Extensive underground studies by Los Angeles indicates that the recovery is possible of about 75 cubic feet per second of water which seeps into the lower valley lands from stream beds and irrigation ditches and irrigated fields, and this water will be used as part of the supply of the aqueduct. Artesian flow has been secured in some deep wells near Independence and additional underground supplies occur in lower portions of the main Owens Valley.

Adobe Meadows form a mountain upland, now used for spring range, for which no water supply is apparent. In much of the valley north of Bishop there is no defined stream, the present small irrigated area being supplied from creeks. While additional land may be watered in the southern end of this section, the irrigation of the larger part is not feasible. Long Valley is the upper agricultural area reported on Owens River, the altitude ranging from 6,500 to 7,000 feet. Most of the valley is now crudely irrigated, the unirrigated area being above the upper river. Round Valley, listed next, lies along Pine, Rock, and Horton Creeks west of Bishop at an altitude of 4,500 to 5,000 feet. The tributary drainage of 190 square miles here furnishes sufficient water for all of the land if properly conserved. Below Bishop and above the intake of the Los Angeles Aqueduct, near Aberdeen, the main irrigated area of the valley is

located, water being supplied by numerous private and incorporated ditches. Present use of water is excessive, and it is considered probable that by more economical methods most of the agricultural land in this portion of the valley could be irrigated. From the aqueduct intake at Aberdeen south to Owens Lake all irrigation not under control of Los Angeles is by water from west-side tributaries from the Sierra. Valley land below the aqueduct is practically controlled by Los Angeles, some land being watered under East Side and Stevens ditches. Surplus rights in the various creeks are controlled by Los Angeles, and increased irrigation can come mainly from better use of the supplies now locally controlled. The remaining area of the Owens Valley country lies south of the lake, toward Olancha. The meager water supply available for irrigation here is derived from small local creeks. Surplus rights here are also controlled by Los Angeles.

Two hundred thousand acres is the area it is estimated will ultimately be irrigated in the valleys of central California east of the Sierra Nevada.

SOUTHERN CALIFORNIA.

In this report southern California is taken to extend southward from Santa Barbara County and the Tehachapi Mountains and from a line across the desert from Tehachapi perpendicular to the eastern boundary of the State. As subdivided for field investigation and report, it is made up of six irrigation zones. The following table lists these zones and summarizes the agricultural and the irrigated areas in each:

Summary of agricultural and irrigated areas of southern California.

Areas.	Agricultural land.	Area irrigated.
	Acres.	*Acres.*
Santa Barbara and Ventura Counties	509,250	49,656
Los Angeles and San Gabriel River lands	441,986	167,454
Santa Ana River lands	876,671	213,407
San Diego County	363,668	19,880
Colorado Desert and River valleys	1,550,750	279,600
Mojave Desert	2,328,000	15,489
Total	6,070,325	745,486

SANTA BARBARA AND VENTURA COUNTIES.

These counties have not so completely utilized their water resources as have the other counties in southern California, due to irrigation being less necessary, although a definite advantage, as now proven and well recognized. Increased irrigation development depends largely on the storage of flood waters and the greater use of underground supplies. Considerable areas are now, however, watered from surface streams, especially in the valley of Santa Clara River in Ventura County.

Summary of agricultural and irrigated areas in Santa Barbara and Ventura Counties.

Areas.	County.	Agricultural land.	Area irrigated.
		Acres.	*Acres.*
Santa Maria Valley	Santa Barbara[1]	147,000	11,441
Cuyama Valley	do	45,000	Nominal.
San Antonio and Los Alamos Valleys	do	15,800	1,750
Lompoc Valley	do	29,300	1,590
Santa Ynez Valley	do	29,000	85
Santa Barbara coastal plain	do	30,750	600
Ventura Valley	Ventura	3,700	1,190
Ojai Valley	do	11,300	850
Upper Ojai Valley	do	1,900	.....
Santa Clara Valley	do	120,800	31,020
Simi Valley	do	13,900	530
Little Simi Valley	do	13,500	600
Las Posas Valley	do	32,300	.....
Connejo Valley	do	15,000	.....
Total	.....	509,250	49,656

[1] Extends into San Luis Obispo County.

The largest surface-water supply of Santa Maria Valley is Santa Maria River. This stream flows westward to the Pacific, draining an area of 1,580 square miles and forming the boundary line between San Luis Obispo and Santa Barbara Counties. The chief tributary of the Santa Maria is the Sisquoc, above which the Santa Maria is known as the Cuyama River. The only available records show the Santa Maria to have carried about 61,000 acre-feet in 1905 above its junction with the Sisquoc.[1] In addition to Santa Maria River, water is obtained for irrigation in Santa Maria Valley from wells in its lower end and from Guadalupe Lake. The valley has an abundant supply of underground waters, and a large increase should come from that source. In addition, an increase should come from storage of flood waters on the Santa Maria and the Sisquoc, although there are no data at hand regarding storage sites. San Antonio and Los Alamos Valleys are traversed by San Antonio Creek; but the principal course of irrigation water is the underflow, which appears to be plentiful. For Santa Ynez and Lompoc Valleys Santa Ynez River is the main surface supply, draining 785 square miles and with a mean annual run-off from 1906 to 1910 of 167,000 acre-feet.[2] Several storage sites are located on the upper river and its tributaries. A considerable portion of the two valleys may be irrigated from underground waters.

The numerous small, short, and torrential streams draining about 100 square miles of the southern slope of the Santa Ynez Mountains furnish the surface water available to the Santa Barbara coastal plain. Tercolote, Winchester, Elwood, Glen Anne, Bartlett, San Pedro, Las Vegas, San Jose, San Antonio, and Alacasadero Creeks and Maria Ygnacio Canyon and Arroyo Burro drain the Galeta Valley. The streams leading to Santa Barbara are those of San

[1] U. S. Geol. Survey Water-Supply and Irrig. Paper No. 177.
[2] U. S. Geol. Survey Water-Supply Paper No. 300.

Roque, Diablo, Mission, Rattlesnake, and Sycamore Canyons. Those leading to Monticeto are Cold Spring, Dinsmore, and Romero Canyons and Ficay Creek. The streams discharging into Carpinteria Valley are those of Toro, Santa Monica, Franklin, Sutten, and Rincon Canyons and Arroyo Parida, Carpinteria and Gobernador Creeks. All of the surface water of these streams is diverted in summer. The city of Santa Barbara has completed a tunnel through the Santa Ynez Range for tapping the supply of Santa Ynez River. There are few opportunities for storage on the southern slope of the Santa Ynez Range, consequently additional irrigation water must come through storage north of the mountains or from underground. A few wells flow. Generally the depth of the wells ranges from 50 to 300 feet, with some near Monticeto 1,000 to 1,400 feet deep. Gibraltar and Mono reservoir sites, in the Santa Ynez River drainage, have respective surveyed capacities of 15,793 and 8,763 acre-feet.[1]

In Ojai and Ventura Valleys the surface supply is Ventura River and tributaries, with a watershed of 190 square miles. Large quantities of floodwaters are discharged to the sea by this river in winter season and one possible reservoir, at the Malilipa site, is known. Some pumping is done from underground sources and this should be possible of extension in Ojai Valley. For Santa Clara Valley water is obtained from underground and from Santa Clara River and Santa Paula, Sespe, and Piru Creeks. At present the principal development is by private pumping plants, water being obtained at less than 50 feet in depth in the valley and at less than 10 feet near the coast. Measurements of the Santa Clara in 1903 indicated a summer flow of 30 to 40 cubic feet per second,[2] and the mean annual run-off is estimated at not less than 200,000 acre-feet. The drainage area is 1,576 square miles. Definite data are not available as to storage possibilities. Simi, Little Simi, and Las Posas Valleys are along Arroyo Simi and Arroyo Las Posas, which are dry most of the year, so that irrigation development must depend almost wholly on what underground waters are found.

Of the 509,250 acres of agricultural land listed in the above table, it is estimated by Mr. C. E. Tait that 322,500 acres will ultimately be irrigated, or about six and one-half times the present irrigated area. The rainfall in the most important of these valleys ranges from 14.34 inches at Santa Maria to 17.32 inches at Santa Barbara, being higher in the adjacent watersheds.

LOS ANGELES AND SAN GABRIEL RIVER LANDS.

These lands are considered together largely because they are within the area that is to be affected by the water supply furnished

[1] U. S. Geol. Survey Water Supply and Irrig. Paper No. 116.
[2] U. S. Geol. Survey Water Supply and Irrig. Paper No. 134.

by Los Angeles Aqueduct, and because they constitute the section that is most closely connected with and tributary to Los Angeles. Considerable land in the suburbs that is more likely to be used for residence tracts than for farming or fruit growing is not included in the agricultural areas listed.

Summary of agricultural and irrigated areas comprising the Los Angeles and San Gabriel River lands.

Area.	County.	Agricultural land.	Areas irrigated.
		Acres.	*Acres.*
San Fernando Valley	Los Angeles	110,500	10,010
San Gabriel Valley	do	78,636	36,536
San Jose Creek Valley	do	10,350	3,401
Los Angeles coastal plain	do	242,500	117,507
Total		441,986	167,454

San Fernando Valley is supplied with but little surface water from its own watershed, but the waters entering from all sides, after disappearing in the sands and gravel, reappear in the southern end of the valley to form Los Angeles River. There is comparatively little drainage to this valley from the south, west, or northwest, Browns Canyon furnishing the most. From the northeast, drainage from the San Gabriel Range enters mainly through Tejunga and Little Tejunga Rivers and Pacoima Creek. Irrigation water is obtained from both canyons and underground, but the larger part of the water of the valley is controlled by the city of Los Angeles. With the completion of the Los Angeles Aqueduct from Owens River Valley an additional supply will be made available. Further development of underground and stored surface supplies will also add to the water for this valley. Present underground supplies are lifted from about 30 feet to 212 feet. For San Gabriel Valley, San Gabriel River, San Dimas Creek, and Big Dalton, Little Dalton, Sawpit, Santa Anita, Little Santa Anita, Eaton, Los Flores, and Rubio Canyons form the principal surface water system. The San Gabriel carries a considerable flow throughout the year, although in summer it and its tributaries are entirely diverted in the canyon for irrigation. There are no flowing wells, but pumping plants are found throughout most of the valley, and in the lower part of the valley the underground waters are abundant.

Two submerged dams in Arroyo Seco have raised the level of underground waters there. Near Irwindale single wells are claimed to discharge upwards of 300 inches. The lift for underground waters varies from only 5 to 10 feet above Bartolo Pass to as high as 225

feet in some parts of San Dimas Wash. Additional water may be brought to San Gabriel Valley from Los Angeles Aqueduct, this being feasible if rights are not oversubscribed in San Fernando Valley. There are no first-class storage possibilities on San Gabriel River, but the spreading of storm waters will replenish the underground supplies. The mean annual flow of San Gabriel River is 104,500 acre-feet[1] and the minimum annual flow of record is 10,000 acre-feet. San Jose Creek Valley is fed by San Jose Creek, which rises in Palomares Cienaga, Pomona, its waters being utilized as both surface and underground flow. In the Los Angeles coastal plain the greater portion of the irrigated area is supplied from pumping plants and flowing wells. The Whittier section is supplied chiefly from San Gabriel River. Ballona Creek waters a small section near the coast. Some water is obtained from Los Angeles River, although nearly all of both surface and underground flow of that stream is diverted above the narrows above Los Angeles. Cahueriga Valley, in the coastal plain, is to be given an opportunity to subscribe for water from Los Angeles Aqueduct, and the same opportunity may be afforded lands near Inglewood and Redondo. The artesian basin in the coastal plain is the largest in southern California, the source being precipitation over the drainage of Los Angeles and San Gabriel Rivers. When flowing wells are developed borings 200 to 700 feet are generally necessary. In most of the coastal plain requiring pumping the lifts usually vary from a few feet to about 63 feet.

Of the 441,986 acres of agricultural land listed above, it is estimated by Mr. C. E. Tait that 381,500 acres, or about 2.3 times the present irrigated area, will eventually be watered, the increased water supply, as indicated, to come most largely from the Los Angeles Aqueduct. The mean rainfall at Los Angeles is 15.60 inches.

SANTA ANA RIVER LANDS.

This division of southern California gets its water supply entirely from within its own watershed. In this it differs materially from the Los Angeles and San Gabriel River lands, which must be largely dependent for further irrigation development on the Los Angeles Aqueduct. Agricultural values here are less governed by residential considerations than about Los Angeles, and both surface and underground waters are utilized with greater thoroughness and economy than in any other considerable area in California, with the possible exception of portions of San Diego County.

[1] U. S. Geol. Survey Water Supply Paper No. 300.

Summary of agricultural and irrigated areas in Santa Ana River lands.

Areas.	County or counties.	Agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Pomona Valley and Cucamonga Plains	Los Angeles and San Bernardino.	131,448	44,823
San Bernardino Valley and Riverside:			
Rialto, Bloomington, and Colton	San Bernardino	48,576	14,250
San Bernardino and Highlands	do	37,817	13,862
Redlands	do	21,830	16,080
Riverside	Riverside	92,300	35,800
Yucaipa Valley	San Bernardino	18,400	2,500
San Gorgonio Pass	Riverside	53,600	5,230
San Jacinto Valley	do	249,700	23,112
Corona	do	18,500	6,750
Orange County: Valley above coastal plain, benches near hills, and upper coastal plain.	Orange	44,500	51,000
Lower lands	do	80,000	
Mesa lands	do	80,000	
Total		876,671	213,407

For Pomona Valley and Cucamonga Plains the water supply is drainage from the Sierra Madre between San Dimas and Lytle Creeks. The chief source for irrigation, especially at Pomona and Chino, is the underground supply, although the surface waters of San Antonio, Cucamonga, Etiwanda, and Day Canyons and of Chino Creek are utilized to the fullest extent available without surface storage other than by a small dam across Evy Canyon, a branch of San Antonio Canyon. Effective work has been done here in spreading flood waters of San Antonio Creek over the coarse gravels below the canyon mouth to be drawn on later by pumping plants. The estimated maximum discharge of San Antonio Creek is 2,000 cubic feet per second, but the average summer discharge in cubic feet per second over a 22-year period is: July, 16.4; August, 14.7; and September, 11.1. The other streams entering Pomona Valley are smaller. The pumping lifts in the cienagas at Pomona and Claremont are 50 to 100 feet in dry years. Below the cienagas the lift is 100 to 400 feet. Some single wells produce 200 inches, but near the foothills the yield is usually not over 50 inches. For San Bernardino Valley the water source is Santa Ana River and tributaries, principally Lytle and Mill Creeks, and Cajon, Twin, City, and Plunge Creeks, and Devils and Waterman Canyons. Warm Creek flows into Santa Ana River in the San Bernardino Basin and Temescal Wash and Chino Creek enter at Rincon. Most of the streams carry water throughout the summer, and all of the normal surface flow is diverted.

San Bernardino Valley contains some wells which it is claimed may produce between 100 and 200 inches of water. Some of the wells in the artesian belt are pumped, as are also many outside of it. All unused waters of the upper basin enter the canyon of the Santa Ana below Rincon and are diverted for use below. Storage capacity to

the extent of 65,000 acre-feet is utilized in Bear Valley and a site with a reported capacity of 35,000 acre-feet is located on South Fork of Santa Ana River. A small reservoir is being built in Mockingbird Canyon. Flood waters from Santa Ana Canyon and Mill Creek are spread over the gravels north of Redlands with good effect on the ground-water levels in San Bernardino Basin. Flood waters are also spread over the gravels at the mouth of Lytle Creek. The mean annual discharge of the Santa Ana is 59,200 acre-feet per second.[1]

Bringing water to San Bernardino Basin from Arrowhead Reservoir, in the Mojave River drainage, has been considered. The water from San Gorgonio Pass is from San Gorgonio, Little San Gorgonio, Noble, Edgar, Patrero, and Millard Creeks, all from San Bernardino Mountains, and all mostly torrential. The streams entering Yucaipa Valley are those of Potato, Water, and Wildwood Canyons. Yucaipa Creek drains the valley to San Timoteo Canyon. Ground waters are brought to the surface in the lower areas. Storage is under consideration on Whitewater River for lands near Banning.

Water for San Jacinto Valley comes from San Jacinto River, including Hemet Lake Reservoir, with a capacity of 8,000 acre-feet, from wells, and for 450 acres near Allesandro, from Mill Creek. For Corona the source is Temescal Creek, Hoags Canyon, and wells in Perris Valley, some of which, in the artesian belt northwestward from San Jacinto, flow. The pump lifts in the valley range from a few feet to about 65 feet. Some wells deliver 100 inches. Storage is proposed on Strawberry Creek, a tributary of the San Jacinto, and the use of Lake Elsinore for storage has been considered. The water supply of the Orange County coastal plain is primarily Santa Ana River diverted in Bedrock Canyon, but in the aggregate large supplies are obtained from both flowing and pumped wells. Santiago Creek, the chief tributary of the Santa Ana, is also utilized, as are Trabuco and San Juan Creeks. Yorba Reservoir is the only storage that has been built for the Orange County coastal plain and this is small. Flood waters are spread in Santiago Canyon and a small reservoir site has been located in Fremont Canyon. Miscellaneous measurements of the Santa Ana at Rincon, above the lower narrows, showed a mean annual discharge there of 118 cubic feet per second.[1] San Juan and Trabuca Creeks have a combined annual discharge of 5,000 to 6,000 acre-feet.

Of the total of 876,671 acres of agricultural land listed in this division it is estimated by Mr. C. E. Tait that eventually 279,000 acres will be irrigated, or only about 1.3 times the area now receiving water.

The mean annual rainfall at some principal points in this division are: Claremont, 16.95 inches; San Bernardino, 15.92 inches; Redlands, 14.94 inches; and Riverside, 10.46 inches.

[1] U. S. Geol. Survey Water Supply Paper No. 300.

SAN DIEGO COUNTY.

This county comprises a district of drier atmosphere, higher summer temperature, and smaller precipitation and stream discharges than the coastal sections to the north. Erratic precipitation results in the need for relatively large storage capacities if all flood waters are to be conserved, and resort to storage furnishes the principal means of obtaining water for irrigation.

Summary of agricultural and irrigated areas in San Diego County drainage.

Areas.	County.	Agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Santa Margarita Valley	San Diego	6,272	1,200
Fallbrook	do	12,800	122
Mountain valleys:			
Temecula	Riverside		
Murietta	do		
French	do		
Los Alamos	do		
Glen Oak	do	95,000	310
Wilson	do		
Terwilliger	do		
Coahuilla	do		
Oak Zone	San Diego		
Escondido Valley	do	13,568	853
San Luis Rey Valley	do	25,600	2,147
San Pasqual Valley	do	3,440	1,040
San Dieguito Valley	do	2,000	150
Santa Maria Valley	do	16,380	102
Poway Valley	do	2,100	20
Bear Valley	do	11,800	200
Green Valley	do	2,450	0
San Marcos Valley	do	33,200	213
Coast Land	do	24,960	270
Linda Vista and Rosedal mesas	do	19,000	0
San Diego River Valleys:			
El Cajon Valley	do	27,100	1,143
Mesa lands	do	12,000	4,700
Mission Valley	do	3,000	1,000
Spring Valley	do	2,600	300
Sweetwater Valley and Chula Vista	do	14,080	4,750
Otay and Tia Juana Valleys and adjoining mesas	do	36,318	1,360
Total		363,668	19,880

Santa Margarita River is the most northerly of the streams of San Diego County. A small storage reservoir waters land in the upper end of Santa Margarita Valley, and there is underground water available there also. Temecula Creek, a branch of the Santa Margarita, waters Temecula Valley, with underground waters at hand in addition. As a rule the small mountain valleys listed are too near the headwaters of the small tributaries to supply enough water for irrigation. About Fallbrook water is obtained from wells, but indications are that the underground supply is not abundant. Here, however, water can be furnished from the Santa Margarita or the San Luis Rey, the proposed Pauma Reservoir being available on the latter stream. A reservoir site has been considered on the Santa

Margarita at the junction of Temecula and Murietta Creeks. For the section comprising San Luis Rey, Escondido, Santa Ysabel, and neighboring valleys and Linda Vista Mesa, San Luis Rey and Santa Ysabel Rivers are the main supply, Escondido Creek draining a small area between those streams. Escondido is the only section that is now well developed, its water coming from San Luis Rey River diverted to Escondido Creek and partly stored in Escondido Reservoir, which has a capacity of 3,500 acre-feet. The Warner Reservoir site is located at the canyon outlet of San Luis River from San Luis Rey Valley. Water is available to San Luis Valley during the winter months from San Luis River as well as from some pumping plants. San Dieguito, San Pasqual, Santa Maria, and Green Valleys are on the Santa Ysabel. There are a few artesian wells in San Pasqual Valley. San Marcos Valley is northwest of Escondido, with underground water the only source. Poway Valley is northeast of La Jolla and is drained by Los Penasquitos Canyon.

An unsuccessful attempt was made to water Linda Vista Mesa from Pamo, Santa Maria, and Dye Valley reservoir sites. The Pamo and Santa Maria sites are now considered in connection with storage in Warner Reservoir to the estimated extent of 229,000 acre-feet annually. The mean discharge of San Luis Rey River at Pala is 50,000 acre-feet annually and of the Santa Ysabel 38,500 acre-feet.[1] For El Cajon, Mission, and Spring Valleys and the mesa lands near by San Diego River is the main surface supply, with a mean annual discharge of 39,600 acre-feet.[1] Cuyamaca Lake Reservoir, with a capacity of 12,000 acre-feet, is used in connection with El Cajon Valley, the Mesa, and Lemon Grove. A reservoir site with a capacity of 10,000 acre-feet is located on North Fork of San Diego River. Underground waters are also available to part of the San Diego River valleys. For Sweetwater Valley and Chula Vista all of the water is secured from Sweetwater River and Reservoir except a little pumped from wells. The mean annual run-off of Sweetwater River is 10,700 acre-feet and Sweetwater Reservoir, recently enlarged from 22,500 acre-feet capacity, is capable of empounding all of the flood waters except in very wet years. Water from Otay and Tia Juana Valleys is chiefly furnished by pumping plants, the mountain waters from their drainage being controlled for use in San Diego, 89,000 acre-feet of storage already having been built in the upper and lower Otay and Moreno Reservoirs and 45,800 acre-feet proposed in Barrett Reservoir.

The estimate made by Mr. C. E. Tait as to the ultimate irrigated area in this division is 87,100 acres, or about 4.4 times the present irrigated area.

[1] U. S. Geol. Survey Water-Supply Paper No. 300.

COLORADO DESERT.

The southern California areas east of the San Bernardino and the San Jacinto Mountains that are entered from Redlands and Riverside through San Gorgonio Pass are much different in character from any of the coastal areas. While the dry hot summers have made the desert areas more difficult to settle than the coastal areas, the luxuriance of agricultural growth there under irrigation is inevitably bringing about irrigation development. Under the range needs of an open country, land holdings are normally large prior to settlement. Where the water sources are underground, irrigation development is a result of individual enterprise, as in much of the coastal country; but where Colorado River is the source of supply the large unit is a prerequisite to any irrigation whatever.

Summary of agricultural and irrigated areas in the Colorado Desert.

Areas.	County or counties.	Agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Coachella Desert:			
Near Palm Springs	Riverside	10,000	50
Below Mission Canyon	do	6,300	.....
Morongo Valley	San Bernardino	8,300	.....
Coachella Valley	Riverside	142,600	3,950
Imperial Valley:			
Main valley	Imperial	510,000	260,000
East-side mesa	do	129,000	
Above canal on west side	do	177,000	
Yuma Indian Reservation	do	18,000	6,500
Palo Verde Valley	Riverside and Imperial	85,000	9,000
Chuckawalla Valley	Riverside	246,000	0
Palo Verde Mesa	do	106,000	0
Calzona	Riverside and San Bernardino.	18,425	0
Chemehuevis Valley	San Bernardino	5,060	0
North from Needles on Colorado River	do	89,065	100
Total		1,550,750	279,600

Coachella Valley and desert is an extension of Colorado Desert, the upper portion also being a continuation of San Gorgonio Pass. Coachella Valley is a portion of Salton Basin and is largely below sea level. Most of the desert is considered nonagricultural. Whitewater River is the principal stream and is perennial, its main tributaries being Mission and Big and Little Morongo Creeks. But little of the water of these streams runs on the surface much below the mouths of their canyons, so that it must be utilized through the medium of wells, mostly in Coachella Valley. Most of the present wells in Coachella Valley flow, but about 150 are pumped. For Imperial Valley the sole water source, aside from a few artesian wells near Holtville and Brawley, is Colorado River, with a mean annual discharge at Yuma of 16,300,000 acre-feet,[1] and with variations in flow from 3,500 to 150,000 cubic feet per second, and its flood period in summer. Colorado River is also the water source for Yuma Indian Reservation

[1] U. S. Geol. Survey Water Supply Paper No. 300.

through the Yuma project of the Reclamation Service, and for Palo Verde and Chuckawalla Valleys, Palo Mesa and the other Colorado River lands listed. Some artesian flow may be developed in Chuckawalla Valley. Water is found in wells on Palo Verde Mesa at a depth of about 130 feet. The Palo Verde and Chuckawalla sections are on or near the Colorado in eastern Riverside and Imperial Counties, Palo Verde Valley being 275 feet below sea level. The ultimate development of these areas as well as of Imperial Valley and the other Colorado River lands depends on the final division of the water of Colorado River, which is both an interstate and international stream.

Of the 1,550,750 acres listed in the Colorado River Desert mesas and valleys, the estimate of the areas that may be ultimately irrigated is 766,500 acres, the largest increases to be in Imperial, Palo Verde, and Chuckawalla Valleys and on Palo Verde Mesa. Rainfall records for the desert regions are not of long standing, but the record for Indio for 31 years shows an annual mean of 2.70 inches. The small rainfall, however, is of no value in agriculture because of its irregularity and of the high rate of evaporation.

MOJAVE DESERT.

This is the largest of the southern California irrigation divisions, but owing to its meager water supplies being of small local value only, it is the least exploited and has the least prospect of future development. Data collected for this division are less complete than for any of the other sections of the State, but present development of underground waters in the desert depressions or so-called dry lakes indicates that more agricultural progress under irrigation will occur there than has been generally supposed. Only the more important areas are listed as agricultural in the table below.

Summary of agricultural and irrigated areas in Mojave Desert and adjacent mesas.

Areas.	County or counties.	Agricultural land.	Areas irrigated.
		Acres.	*Acres.*
Mojave River:			
Mojave River Valley	San Bernardino	195,000	[1] 10,000
Mojave River Sink	do	40,000	
East Mesa	do	130,000	
West Mesa	do	545,000	
Antelope Valley	Los Angeles and Kern	485,500	4,629
Mesquite Valley	San Bernardino	30,000	0
Ivanpah Valley	do	223,000	0
Branwell Sink	do	154,000	0
Southwest from Needles	do	115,000	0
Do	Riverside	115,000	0
Desert Springs Valley	Kern	119,000	200
Indian or Salt Wells Valley	do	112,000	500
Rose Valley	Inyo	21,000	100
Twelve Mile or Chicago Valley	do	8,100	60
Pahrump and Stewart Valleys	do	20,400	0
Amargosa Desert	do	15,000	0
Total		2,328,000	15,489

[1] Irrigated areas scattered and not completely canvassed, but believed to exceed 10,000 acres.

The area estimated by Mr. C. E. Tait to be ultimately irrigated in the Mojave Desert region is 113,000 acres, or about 7.3 times the area now irrigated. Estimates are especially difficult in a section of the character of this one. As in the Colorado Desert region, rainfall is so independable here as to be of little more than passing value in agriculture except as stored in desert and mountain canyons or underground when it happens to occur.

SUMMARY OF IRRIGATION RESOURCES.

The foregoing pages give the results, largely only statistical, of the inquiry into the irrigation resources of California made by the Office of Experiment Stations to assist the State Conservation Commission in its presentation regarding natural resources of California. In interpreting these results it must be remembered that the field work immediately applicable to the investigation has been done within the relatively brief period of one year and at the relatively small cost for covering the 334 separate valleys and areas reported of about $10,000. The limits of this publication have permitted only the listing of the various irrigable agricultural areas, brief statements as to acreages now irrigated, and as to the water sources for irrigation available to each of the areas, and estimates of the areas that it seems likely will be irrigated in the future. While the estimates of areas that may be irrigated in the future can be no more than approximations, present standards of irrigation practice have been followed in reaching them, with the possible exception of the desert sections of southern California, which the writer of the report on southern California was unable to visit personally and about which water-supply data are meager.

The accompanying irrigation maps of northern, central, and southern California (Pls. I, II, and III) show the location and extent of the various agricultural areas that are within the general limits of an irrigation water supply and topographically and agriculturally suited to irrigation, as well as the approximate or the exact location of the lands that are now irrigated and of the principal canals supplying water to them. Care has been taken to name on the maps all of the streams of more than minor importance in irrigation, and also the important streams outside of the irrigation belts, in order that the maps shall have something of a permanent local value as well as an immediate general value in connection with proposed irrigation legislation.

It has been felt in some parts of California that the State has already approached the limit of its irrigation development. Some have maintained that northern California does not require irrigation and should, therefore, not be considered in the framing of water laws. For detail information about the irrigation needs and possibilities of

the various areas reference must be made to the full reports presented to the Conservation Commission for publication. It is, however, believed that reference to the tables and other data heretofore presented in this bulletin and to the irrigation maps will make clear not only that the irrigation resources of California are yet far from being utilized, but also that irrigation and its problems either control or widely influence agriculture in every section of the State to which water can be made available, with the possible exception of the immediate small coast areas of the north.

The tabular summary inserted on page 11 showed the acreages of valley, plains, and foothill agricultural lands in northern California of importance from the standpoint of irrigation, together with the acreage irrigated. These areas were arranged according to six irrigation divisions or zones, arranged as to the similarity of irrigation and other agricultural conditions rather than strictly according to county or hydrographic lines. The summary showed 4,621,200 acres of valley, 790,000 acres of plains, and 789,000 acres of Sierra foothill agricultural land topographically irrigable within zones of water supply for irrigation. Of this, 487,805 acres were reported irrigated, with 161,930 acres of this in the northeastern plateaus and valleys of Modoc and Lassen Counties, 123,500 acres in Sacramento Valley, 103,850 acres in the north-central mountain valleys of Siskiyou, Trinity, and Shasta Counties, 50,600 acres in the high Feather River valleys, 45,250 acres in the Sierra foothills, and 2,675 acres in the northern coastal counties. The total area estimated as being likely to be irrigated in northern California in the future is 3,450,000 acres, or about 53 per cent of the whole. Of this, 100,000 acres are credited to the northern coastal counties, 250,000 acres to the north-central mountain valleys, 300,000 acres to the northeastern plateau region, 100,000 acres to the Feather River valleys, 200,000 acres to the northern Sierra foothills, and 2,500,000 acres to Sacramento Valley.

Counting the four divisions or irrigation zones of central California as listed on page 23, a total of 9,665,000 acres of valleys, plains, and foothill agricultural land are reported, of which 1,959,355 acres were reported irrigated on the basis of the 1909 irrigation census, supplemented by additional data gathered in 1911 in the central coastal and the Sierra foothill areas and in the valleys east of the Sierra Nevada, and brought down to 1912 for the areas in San Joaquin Valley. Of the irrigated areas 82,000 acres are in the central coastal valleys, 1,728,975 acres are in San Joaquin Valley, 10,620 acres are in the Sierra foothills above San Joaquin Valley, and 137,760 acres are in the valleys east of the Sierra foothills. The total of the areas which it is estimated will ultimately be irrigated in the four zones or divisions is 4,300,000 acres, or about 44 per cent of the whole. Of this, 200,000 acres are credited to the coastal valleys, 3,850,000 acres to the San

Joaquin Valley, 50,000 acres to the Sierra foothills, and 200,000 acres to the valleys east of the Sierra.

Counting the six divisions of southern California listed on page 31, the total area of agricultural land reported in that portion of the State is substantially 6,000,000 acres, with 745,486 acres irrigated. Of the area irrigated, 49,656 acres are in Santa Barbara and Ventura Counties, 167,454 acres are in the valleys of Los Angeles and San Gabriel Rivers, 213,407 acres are in the drainage of Santa Ana River, 19,880 acres are in the San Diego County drainage, 279,600 acres are in the Colorado River and Colorado Desert areas, and 15,489 are in the Mojave Desert region. The total of the areas that it is estimated by Mr. C. E. Tait will ultimately be irrigated in southern California is substantially 1,949,600 acres, or about 33 per cent of the whole. This area is credited to the six different divisions as follows: Santa Barbara and Ventura Counties, 322,500 acres; Los Angeles and San Gabriel River lands, 381,500 acres; Santa Ana River lands, 279,000 acres; San Diego County drainage, 87,100 acres; Colorado Desert and River Valleys, 766,500 acres; Mojave Desert region, 113,000 acres.

For all California a final summary of areas shows the following:

Summary of agricultural areas in California within the general zones of irrigation water supply, areas irrigated in 1909, 1910, and 1911, corrected to 1912 for the larger and more important areas, and the areas it is estimated may eventually be irrigated.

Division.	Agricultural areas in irrigation zones.	Areas irrigated.	Total areas it is estimated may ultimately be irrigated.	Approximate per cent of total estimated as ultimately irrigable.
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Northern California	6,200,200	487,805	3,450,000	56
Central California	9,665,000	1,959,355	4,300,000	44
Southern California	6,000,000	745,486	1,949,600	33
Total	21,865,200	3,192,646	9,699,600	44

If the Sierra foothill agricultural areas were eliminated from the above summary, confining the figures to valley, plateau, and desert lands, the total would be 20,346,200 acres, the present irrigated area 3,136,776 acres, and the area it is estimated may ultimately be irrigated 9,449,600 acres. If the rolling plains of the west side of Sacramento Valley were further eliminated, the total valley area of the State would become approximately 19,000,000 acres, or about 3,000,000 acres more than the most complete figures heretofore available.[1] This shows agricultural valley lands of California alone to be about 19 per cent of the total area of the State, instead of previous estimates of 20 per cent when including the rolling agricultural lands of the Coast Range not considered in this study.

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 237.

USE OF WATER FOR IRRIGATION IN TYPICAL SECTIONS OF CALIFORNIA, 1912.

The preceding pages have been devoted to a reconnoissance inventory of the irrigation resources of California, statements of the present extent of their utilization, and approximate estimates of the areas that it seems reasonable may ultimately be irrigated. The remainder of this report is devoted to a discussion of the character of present utilization, mainly as illustrated by development in six typical sections of the State. In preparing this discussion, as well as in selecting the typical localities cited, the purpose in view has been to present essential facts regarding the character of the use of water under present irrigation laws, rather than to describe the details of irrigation practice, or to set forth the results that have been obtained, or the values that have been created as a consequence of irrigation.

The following sections of California were selected for measuring diversions of water for irrigation and for studying the character of its use in 1912, it being believed that they cover in general the wide range of irrigation conditions that are to be found in the State, with the possible exception of San Diego County and the desert regions of the south: Shasta Valley; Feather River Valley; San Joaquin Valley along San Joaquin River and tributaries; a part of Santa Clara Valley, Santa Clara County; the valley of Santa Clara River, in Ventura County; and the areas in San Bernardino, Riverside, and Orange Counties that are mainly dependent for their irrigation supplies on Santa Ana River and its principal tributaries. Shasta Valley is typical of the mountain valleys and areas of northern California having the shorter irrigation season, and in which the crops grown are thus far generally grains and forages, and the use of water generally wasteful. Feather River is typical of the extensive areas of Sacramento Valley for which the water supplies are ample for complete development and in which the need or value of irrigation have only generally been appreciated and irrigation has only been started on a considerable scale within the past decade. The portion of San Joaquin Valley covered represents conditions where the possibilities are large, although the water supplies are insufficient for complete irrigation, and where economical utilization is really only just beginning. Santa Clara Valley, in Santa Clara County, is one of the highly developed orchard sections where a few years ago irrigation was not considered necessary, but where now much of the surface flow of tributary streams is utilized for winter and spring irrigation and where large expense is incurred in raising water for irrigation from underground sources. The valley of Santa Clara River, in Ventura County, has all of the crops, nearly

all of the conditions of water supply, and about the same degree of need for irrigation water as the coastal areas of Santa Barbara and Ventura Counties. In the valley of Santa Ana River are probably to be found as high irrigation values, as extensive efforts to conserve water, as economical use, and as complicated conditions of ownership as are to be found in the State, conditions along the Santa Ana being thoroughly typical of the coastal plain extending from Los Angeles and vicinity to Redlands and from Pomona Valley to the beginnings of San Diego County.

SHASTA VALLEY.

Field work in Shasta Valley was done by N. M. Stover. In studying the use of water in this valley Little Shasta Valley was considered a part of the main valley. Together Shasta and Little Shasta Valleys form an agricultural area that extends from near the base of Mount Shasta northward about 30 miles to Klamath River. (Pl. X.) April to September forms the usual irrigation period. The season of 1912 was characterized by little rain during the previous winter months and abundant rain in the spring and early summer. As a consequence of the late spring, very little grain was irrigated, although the usual practice on the meadows was followed, the water in many cases being allowed to run continuously from early spring until haying time, usually about July 15. After the meadows were cut over water was usually again turned onto them for pasturage purposes, the result being that a majority of the ditches diverted water whenever it was available over a 5-month or 6-month period.

Four divisions of the valley were considered: Shasta Valley above Big Spring, Shasta Valley about Big Spring, Shasta Valley below Big Spring, and Little Shasta Valley.

SHASTA VALLEY ABOVE BIG SPRING.

For Shasta Valley above Big Spring the water sources were North, Middle, and South Forks of Shasta River, and Boles, Beaughan, Jackson, Carrick, Parks, and Willow Creeks. All of the diversions from these sources are by private ditches, only one, the Edson-Foulke ditch, carrying water to a large area. Measurements were made of the diversions from all of these streams in 1912, as indicated in the following summary:

Summary of measurements of diversions from Shasta River and tributaries above Big Spring, 1912.

Stream.	Ditch.	Area irrigated.	Crop.	Amounts of water carried on dates of measurement.	Amount of water in notice of appropriation.	Remarks.
		Acres.		*Cubic feet per second.*	*Cu. ft. per second.*	
North Fork of Shasta River.	Dow No. 2	45	Pasture	May 30, 5.59; June 7, 4.89; June 27, 2.29; July 11, 0.68; July 24, 0.5	No filing found	This tract also receives water from Dow ditch No. 3.
Do	Scott	350	Meadow	May 20, 16.54; June 7, 15.85; June 27, 7.93; July 11, 5.51; July 24, 4.81.	do	Water carried part way in Edson-Foulke ditch, surplus being used on pasture.
Do	Durney No. 1	(part of) 150	Pasture	Mean of daily readings June 7–24, 0.29; June 25, dry; maximum diversion, 0.66.	do	Land irrigated also receives water from springs and from ditch from middle fork.
Middle Fork of Shasta River.	Durney No. 2	(part of) 150	do	Mean of daily readings June 7–27, 0.31; June 28, dry; maximum diversion, 0.64.	do	
Do	Dobkins No. 4	15	do	May 29, 2.83; mean of daily readings June 5–July 10, 2.30; maximum diversion, 3.15.	do	
South Fork of Shasta River.	Dobkins No. 1	30	do	Mean of daily readings June 5–July 10, 0.42; maximum diversion, 0.69.	do	Irrigation commenced June 1.
Do	Dobkins No. 2	15	do	May 29, 1.59; June 5, 1.21; June 27, 0.50; July 11, 1.2	do	
Do	Dow No. 1	80	Meadow	Mean of daily readings June 5–24 (water out June 13–17), 1.91; June 25, dry; maximum diversion, 2.23.	do	Irrigation begun June 2.
Do	Dow No. 1	20	Pasture			
Do	Dobkins No. 3	40	do	June 5, 1.19; June 9, 0.92; June 17, 0.95; June 27, 0.95; June 28 and 29, 0.92; July 2, 0.92; July 11, 0.92.	do	
Shasta River	Dobkins No. 5	80	Meadow	May 28, 4.12; June 5, 2.44; July 11, 2.07	do	Water run at irregular intervals.
Do	Dow No. 3	(part of) 45	Pasture	June 27, 1.73; July 11, 1.20; July 24, 0.76	do	Land irrigated also receives water from Dow ditch No. 2.
Do	Edson-Foulke	1,820	Alfalfa and meadow.	June 5, 27.83; June 27, 35.63; July 11, 27; July 24, 25.16	do	Also receives water from Parks and Willow Creeks. One-fourth of water carried delivered to Webb extension to Foster, Armstrong, and Russell ranches, remainder going to Gazelle ranch of Edson-Foulke Co.
Do	Dobkins No. 6	140	Pasture	May 29, 10.09; June 27, 2.07; July 11, 0.22; July 24, 0.22	do	
Do	Kasshafer No. 1	80	do	June 5, 11.93; June 27, 1.13; July 11, 3.38; July 24, 2.15	do	
Do	Kasshafer No. 1	138	Meadow			
Do	Kasshafer No. 2	4 or 5	Pasture	July 24, 0.83	do	Measuring weir washed out. Acreage irrigated is that of usual years.
Do	Cavanaugh No. 1	10 to 20	do	June 6, 3.08; June 28, 0.84; July 11, 0.29; July 24, dry	do	
Do	Cavanaugh No. 2	30	Garden and hay.	Ditch dry each time visited	do	Ditch runs at irregular intervals. Land irrigated also receives water from Boles Creek.

Summary of measurements of diversions from Shasta River and tributaries above Big Spring, 1912—Continued.

Stream.	Ditch.	Area irrigated.	Crop.	Amounts of water carried on dates of measurement.	Amount of water in notice of appropriation.	Remarks.
Shasta River—Con.		*Acres.*		*Cubic feet per second.*	*Cu. ft. per second.*	
Do	Alexander	20	Pasture	June 6, 3.11; June 28, 1.71; July 12, 2.37; July 23, 2.15	No filing found	Ditch runs very constantly, waste being carried to Mills pasture to north.
		10	Grain			
		25	Alfalfa			
Do	A. Dennis	18	Meadow	June 6, 4.48; June 28, dry; July 12, 1.79; July 23, dry	do	Water run at irregular intervals.
Do	F. Smith	14	do	June 6, 3.74; June 28, dry; July 12, 1.08; July 23, 1.80	do	Water diverted June 6 in excess of ditch capacity.
		2	Garden			
Do	McMahon No. 1	30	Meadow	Mean of daily readings June 6–July 10 (water off June 28 and 29), 2.10; maximum diversion, 2.89.	do	
Do	McMahon No. 2	9	Alfalfa and garden.	Mean of daily readings June 7–July 10 (water off June 30–July 8), 0.74; maximum diversion, 1.57.	do	
Do	McMahon No. 3	35	Meadow	May 27, 6.58; June 28, 2.06; July 12, 1.95; July 25, 0.85	do	One branch of ditch used for stock water and for waste back to river.
Do	Aurbaugh	837	Meadow and pasture.	May 27, 15.24; June 8, 22.10; June 28, 9.88; July 12, 9.64; July 25, 5.21.	24	Water carried by ditch divided equally among four parties. Two springs with estimated flow of 1 cubic foot per second also used.
Do	Mills No. 1	(part of) 110	Meadow	June 8, 10.47; June 28, 5.81; July 12, 3.37; July 25, 4.38	No filing found	Irrigates same land as Mills ditch No. 2.
Do	Mills No. 2	(part of) 110	do	June 17, 2.15; June 28, 2.36; July 12, 2.36; July 23, 4.06	do	Irrigates same land as Mills ditch No. 1.
Do	Mills No. 3	75	do	June 7, 12.95; June 28, 5.22; July 12, 4.35; July 23, 5.56	do	This ditch carries large amounts of waste water from Aurbaugh ditch.
Do	A. E. Rowe No. 1	260	do	June 17, 15.22; June 28, 15.63; July 12, 4.60; July 23, 4.76	5	Early in season water from this ditch wasted across Mills meadow.
Do	A. E. Rowe No. 2	95	do	June 17, 3.43; June 28, 2.07; July 12, 2.93; July 24, 0.38		Water run at irregular intervals.
Do	J. L. Jones	45	Alfalfa	June 17, 2.68; June 28, 1.26; July 12, dry; July 25, 2.59; Aug. 6, 2.60.	6	Small additional area in several tracts also irrigated by this ditch, largest being 5 acres of alfalfa.
Do	Williams	390	do	June 17, 5.34; June 28, dry; July 12, 3.05; July 25, 5.25; Aug. 6, 3.	30	Also known as Nichols ditch.
Do	Miller & Dunlap	150	do	June 17, 3.36; June 28, 4.05; July 12, 1.58; July 25, 3.26	10	
Do	Nelson Dennis	110	do	June 18, 3.71; June 28, 3.67; July 12, 2.02; July 25, dry	No filing found	
Do	Hannah Dennis	140	do	June 18, 13.02; June 28, 10.23; July 12, 3.07; July 25, 7.20	do	
Do	E. D. Terwilliger	57	do	June 18, 2.5; June 10, 1.66; July 13, 1.19; July 25, 1.39	do	

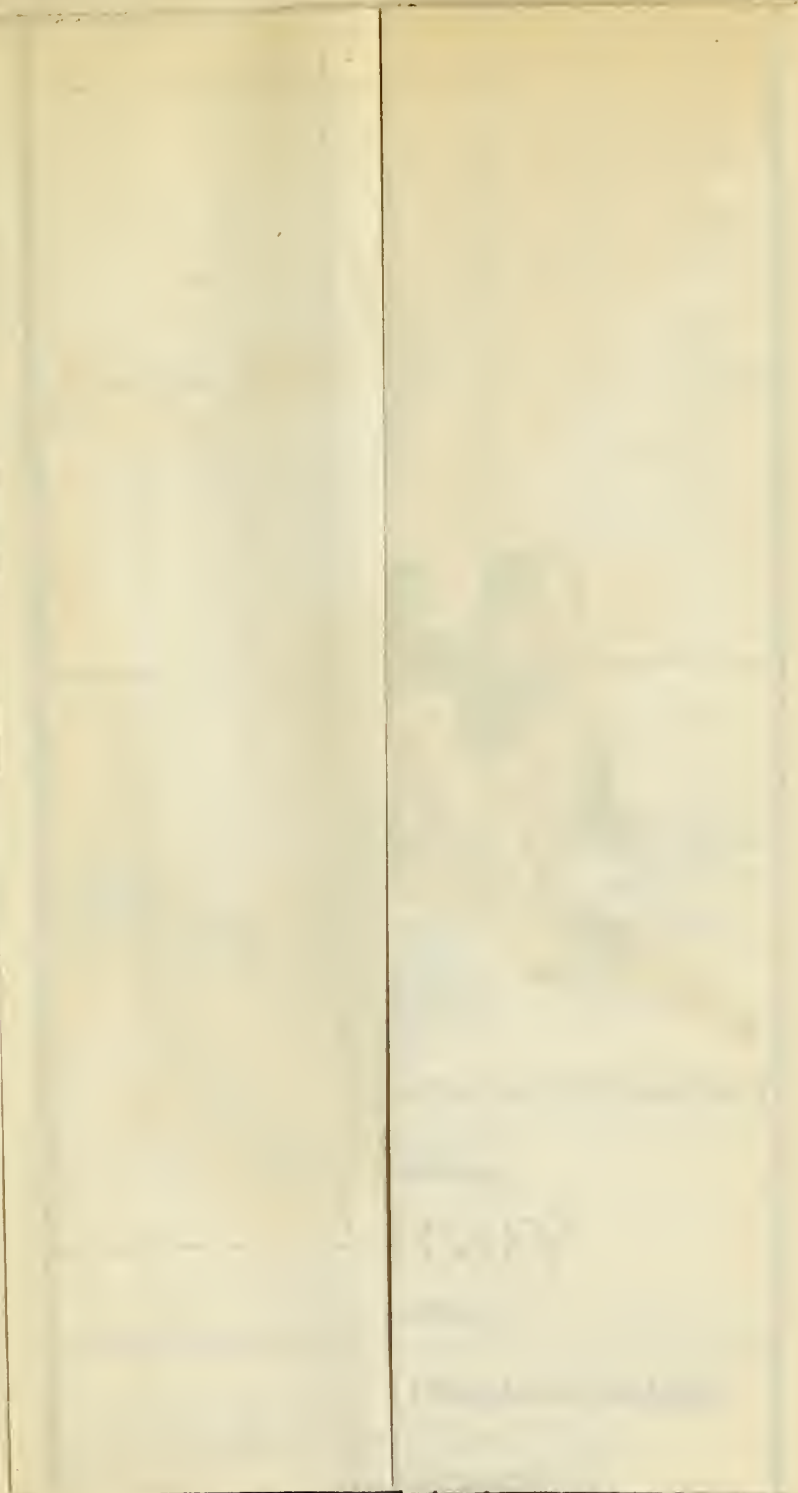


PHOTO-LITH. BRITTON & REY, S.

U.S. DEPT. OF AGR., BUL. 254 OFFICE OF EXPT. STATIONS. IRRIGATION INVESTIGATIONS

U.S. Dept. of Agriculture ~ Office of Experiment Stations

IRRIGATION INVESTIGATIONS

IRRIGATION DEVELOPMENT from SHASTA AND LITTLE SHASTA RIVERS and ADJACENT SPRINGS

CALIFORNIA

Prepared in Cooperation with the

CONSERVATION COMMISSION OF CALIFORNIA

1912

LEGEND
- Irrigation Canals
- Pumping Plants
- Lands Irrigated 1912
- Contours
- Unirrigated Agricultural Land

Scale of Miles: 0, ½, 1, 2

Klamath River
Yreka Creek
YREKA
Montague
Little Shasta River
Shasta River
Grenada
Gazelle
Mayten
Big Spring
Little Spring
Cedar Lake
Willow Creek
Carrick Creek
Bolea Creek
North Fork Shasta R.
Scobey

T46N R7W
T46N R6W
T45N R7W
T45N R6W
T44N R7W
T44N R6W
T43N R7W
T43N R6W
T42N R7W
T42N R6W
T41N R7W
T41N R6W
T41N R5W
T41N R4W
T42N R4W
T45N R5W
T45N R4W

PHOTO-LITH. BRITTON & REY, S.F.

SHASTA VALLEY ABOUT BIG SPRING.

Big Spring forms the most important source for the sustained late summer flow in lower Shasta River. Numerous diversions are made from the water of this and Little Spring, these being summarized in the table below as measured in 1912.

Summary of measurements of diversions from Big and Little Springs, 1912.

Source.	Means of diversion.	Area irrigated.	Crop.	Amounts of water carried on dates of measurement (cubic feet per second).	Amount of water in notice of appropriation.	Remarks.
		Acres.			*Cu. feet per sec.*	
Big Spring.....	Stallcup pumping plant.	310 65	Alfalfa.... Grain.....	June 18, 7.69; Aug. 6, 7.73.	4	Water lifted 27 feet by No. 10 centrifugal pump with 40-horsepower motor. Grain received one irrigation in May only.
Do.....	Louie & Rose ditch.	300	Alfalfa....	June 19, 12.43; June 28, 6.48; July 13, 9.26; July 26, 7.35.	26	Land irrigated also received some water by means of a current wheel.
Do.....	Louie Bros. ditch.	30	Meadow...	June 19, 4.17; June 28, July 13 and 26, dry.	(1)	Water run at irregular intervals.
Big Spring Branch.	Rose current wheel.	Part of 300.	Alfalfa....	July 13, 1.10; July 26, 1.19.	4.8	This diversion irrigates same land as watered by Louie & Rose ditch.
Little Spring...	James Dennis ditch.	72 40	Alfalfa.... Meadow...	June 19, 4.06; June 29, 4.73; July 13, 4.58; July 26, 5.18	8	
Little Spring Branch.	J. Dennis & Louie Bros. ditch.	120	Pasture...	July 13, 2.13; July 26, 2.31.	8	When water is not diverted by this ditch it is run down to Louie Bros. ditch.
Do.....	Louie Bros. ditch.	40 60	Alfalfa.... Meadow...	June 19, 4.37; June 29, 0.92; July 13, 1.69; July 26, 1.61.	(1)	Receives water when J. Dennis & Louie Bros. ditch not running.

[1] No filing found.

SHASTA VALLEY BELOW BIG SPRING.

Diversions in this portion of Shasta Valley are for lands lying along the river bottoms. Beginning with Gilpin ditch the areas irrigated are only partially covered by the ditches listed below, water also usually being received from numerous sloughs and overflows that it was not feasible to measure, making the acreage reported irrigated larger than above Gilpin ditch in proportion to the water diverted by the ditches.

Summary of measurement of diversions of water from Shasta River below Big Spring, 1912.

Ditch.	Area irrigated.	Crops.	Amounts of water carried on dates of measurement (cubic feet per second).	Amounts of water claimed in notices of appropriation.
	Acres.			*Cu. feet per sec.*
Mary Dennis [1]	80	Alfalfa	July 9, 2.72; July 26, 3.03	10
Granada	400	Meadow and alfalfa	June 19, 10.15; June 29, 21.89; July 9, 9.40; July 26, 6.94.	30
Gilpin	140	Meadow and pasture	June 24, 0.98; July 6, dry; July 15, 0.64; July 30, dry.	10
Frank King	160	....do	June 24, 0.27; July 6, 1.04; July 15, 1.04; July 30, 1.25.	4
Dan Lucas (current wheel).	30	Garden, alfalfa, and pasture.	June 24, 0.53; July 6, 0.44; July 15, no diversion; July 30, 0.49.	(2)
Lewis	35	Garden, alfalfa, and meadow.	July 6, 1.17; July 15, 0.91; July 30, 0.72	3
G. Lemas (current wheel.)	28	Garden and meadow	June 24, 0.48; July 6, 0.25; July 15, 0.25; July 30, 0.36.	(2)
Lewis (current wheel).	20	Meadow and alfalfa	June 25, 0.44; July 6, 0.25; July 15, 0.25; July 30, 0.52.	(2)
Flock and Payot	210	Meadow and pasture	June 25, 6.91; July 6, 5.6; July 30, 9.99	20
Antonio	130	Meadow	June 25, 14.81; July 6, 1.26; July 30, 7.70 [3]	12.80
Foster (current wheel).	55	.....do	June 6, 0.16; July 15, 0.19; July 30, 0. 25	(2)

[1] No water carried until late in summer.
[2] No filing found.
[3] This large diversion due to recent storm.

LITTLE SHASTA VALLEY.

Sixteen ditches diverted water in Little Shasta Valley in 1912, two receiving water from Cleland Spring, one from Evans Spring, one from Bassey Branch Spring, two from Martin and Jim Springs, and the others from Little Shasta River. The largest of the springs is Cleland Spring, the total nearly continuous diversion from this spring in 1912 by F. Terwilliger and Haight, Deter, and Terwilliger ditches being 13.5 cubic feet per second. Little Shasta is the most compact center of irrigation in the valley, the area watered in 1912 being 4,498 acres, not including land irrigated with waste water from ditches.

Summary of diversions from Little Shasta River and adjacent springs, 1912.

Source.	Ditch.	Area irrigated.	Crop.	Total diversion, Apr. 1 to Sept. 30.	Depth of water applied, Apr. 1 to Sept. 30.	Area irrigated per cubic foot of water per second diverted.	Maximum measured diversion in 1912.	Amount of water claimed in notice of appropriation.
		Acres.		*Acre-feet.*	*Feet.*	*Acres.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
Little Shasta River.	Terwilliger	180	Alfalfa and meadow.	291.65	14.50	24.3	1.89	[3]
Cleland Spring	do [1]			[2]2,330.21			8.40	
Little Shasta River.	Dimmick	15		[4]70.05	4.67	62.5	0.43	[3]
Do	Soule & Terwilliger.	365	Meadow and pasture.	2,403.58	6.59	55.5	12.00	1.0
Do	Company	625	Meadow and miscellaneous.	3,079.44	4.92	76.9	20.50	
Do	Babcock, Soule & Martin.	418		2,165.68	5.18	77.0	16.40	13.5
Do	Hart & Haight	1,665	Meadow and pasture.	[4]435.43	2.19	200.0	2.59	5.0
Do	Hart & Hoyt			[4]2,088.12			15.00	10.0
Evans Spring	Evans			[2]1,118.53			3.07	
Little Shasta River.	Smith	100	Meadow	[5]			5.65	[3]
Do	Grisez	150	Hay and pasture.	[5]			[6]5 to 6	7.0
Do	Hart		Meadow and pasture.	[6,7]			11.25	5.0
Cleland Spring	Haight, Deter & Kegg.	645		[2]2,508.06	3.89	100.0	[8]8.17	6.0
Bassey Branch Spring.	Kegg	170		[2]964.71	5.67	66.6	[9]5.08	5.4
Martin and Jim Springs.	Martin [3]	165	Meadow	[2]1,446.22	8.76	41.6	4.46	[10]Up to 6
Total or average.		4,498		18,901.68	4.20	78.2		

[1] Also used for power purposes.
[2] September discharge estimated.
[3] No filing found.
[4] April discharge estimated from May measurements.
[5] Record not complete.
[6] Estimated.
[7] June 1, carrying 11.25 cubic feet per second; June 22, 3.47 cubic feet per second; July 27, 0.91 cubic feet per second.
[8] Includes some water from Bassey Branch Spring.
[9] Includes some waste water.
[10] By court decree.

SUMMARY.

Excessive use of water and a low duty would be expected in Shasta Valley from the general appearance in the field in 1912. Both excessive use and a low duty obtained. The first measurements of diversions were made on April 17, the April flow in the ditches that are reported being estimated from measurements made after that date and from a general knowledge of conditions prior to it. A relatively large area in Shasta Valley is devoted to native meadows and to pastures, the practice of keeping water running over these fields until haying time being not uncommon. Where water was not run continuously, intervals of 10 days to two weeks elapsed between irrigations.

The lowest duty in Shasta Valley in 1912 was found on the sloping ranches nearest the foothills. The highest duty was under the Hart, Evans, and Haight, Hart, and Hoyt ditches, largely due to including a considerable area of meadow over which water was run that might otherwise have been wasted back to the river. If these ditches were omitted from the table of diversions from Little Shasta River and springs, the average depth of water applied in 1912 would become 5.39, and the average area irrigated per cubic foot per second would become 63.05.

Careful account was kept of the water used on the ranches of Edward Stallcup & Sons, near Big Spring, and B. M. Martin, under Martin Spring, in Little Shasta Valley.

On the Stallcup ranch 7.71 cubic feet of water per second was applied on 310 acres of alfalfa for 183 days, making a depth of 9.03 feet over the whole area, or at the rate of 1 cubic foot per second for 43.4 acres. The soil on this ranch is volcanic and very sandy, causing the water to be taken up rapidly. The check system of applying water was not followed, but one man gave his entire time to the distribution of the water. The pumping plant did not run every day, but as the time it was not run approximately counterbalanced the use of water during the 183-day period in giving 65 acres of grain one irrigation, no allowance is made for days idle. Two crops of alfalfa were cut from the land irrigated, the first one averaging a measured yield of 461 tons, or about 1.5 tons per acre.

The measurements of use on the Martin ranch show the application between April 1 and September 1 of 1,213 acre-feet of water on 165 acres, an average of 7.35 acre-feet per acre, or at the rate of 41.6 acres per cubic foot per second. The irrigated crops here were meadow and pasture.

The ranches in Shasta Valley vary in size from a quarter section to several sections, the smaller ones generally being devoted to dairying and the larger ones to stock raising.

In the tables summarizing the measurements of diversion in 1912 the amount of water claimed in notices of appropriation that have been filed with the recorder of Siskiyou County were given for comparison with the maximum diversions measured during the season. Where no filings are noted, none could be found in the records, although they were searched carefully. The filings are locally considered to have very little importance, and many who have used water continuously for a long period have refrained from making filings for fear their rights would thereby be made to date from the time of filing.

The irrigation practice followed in Shasta Valley results in large amounts of water being wasted, and it is not at all uncommon to find tules or weeds growing in the lower portions of the meadows. As the

waste water from the fields seeps away in many small streams its measurement was not possible. The use of the waste water by those having no conceded rights to it is a common practice, resulting in a considerable area of pasture being irrigated that otherwise would be dry. This is true in marked degree in the western end of Little Shasta Valley, where a number of good pastures are to be found that have no other source of irrigation supply.

The waters of Shasta Valley have been the subject of much litigation, but it was not possible during the season of 1912 to make a thorough study of it.

FEATHER RIVER.

The field work in the studies of the use of water from Feather River in 1912 was done by R. V. Meikle. Records were kept of all diversions from the river and its main tributary for use in irrigation in the main valley and adjacent plains and foothills (Pl. XI). The table following lists the systems making the diversions, shows the source of the supply, the areas and crops irrigated, the total quantities diverted, the amounts of water filed on, and the gross duty in 1912:

Summary of diversions of water for irrigation from Feather River and principal tributaries, 1912.

Company.	Source.	Areas irrigated.	Crops irrigated.	Total quantities diverted.[1]	Average diversion during month of maximum use.	Amounts of water claimed in notices of appropriation.	Average depth of water applied.	
							Complete systems.	Laterals.
		Acres.		*Acre-feet.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Feet.*	*Feet.*
South Feather Land & Water Co.	Lost, Pinkard, and Orlera Crecks.	1,200	Oranges, olives, and deciduous fruits.	6,998	25	120	5.83	3.64
Golden West Tunnel, Mine & Milling Co.	Sucker Run Creek.	25	Garden truck and deciduous fruits.	[2]	.....	.....	.....	4.00
Palermo Land & Water Co.	South Fork.....	1,900	Oranges, olives, peaches, garden truck.	11,506	45	60	6.06	4.67
Oro Water, Light & Power Co.	West Branch.....	810	Oranges, olives, and deciduous fruits.	[3]	60	100	.....	[4] 3.00
Sutter-Butte Canal Co.	Feather River.....	14,000	Rice, alfalfa, deciduous fruits, and miscellaneous crops.	105,382	230	2,000	7.53	4.90
Totals and averages.....	.....	17,935	.....	123,886	.....	.....	[5] 7.24	[5] 4.78

[1] Diversions for October estimated.
[2] Principal diversion for mining, so total not given.
[3] Diversion for power purposes and municipal supply of Oroville also. About 60 cubic feet per second diverted until Aug. 1, with diversion less after that date.
[4] Includes domestic supply of Thermalito.
[5] Does not include Golden West or Oro companies.

In explanation of the quantities of water used under the canal systems listed above, it should be stated that only Sutter-Butte Canal was originally built for irrigation. The canals of the South Feather Land & Water Co. form the old Forbestown mining system, and the water diverted is carried for much of the distance between the first intake and the places of use in natural stream beds, resulting in a loss in 1912 of 2,627 acre-feet, or 38 per cent of the quantity diverted. Some of the water diverted is carried 61 miles. Palermo Canal was constructed in 1854 for mining, and the water carried by it is run from 22 to 36 miles before use. In the first 22 miles the losses in 1912 amounted to 23 per cent of the diversion. The system of the Oro Water, Light & Power Co. carries water about 30 miles in old mining ditches. Three small reservoirs are a part of the system, and the water carried is used in two power houses for generating an aggregate of 3,700 horsepower of electric current. Sutter-Butte Canal is constructed to cover a much larger acreage than is now irrigated, making the conveyance of water in it necessarily uneconomical. The main canal is about 20 miles long and its laterals aggregate 75 miles. The loss from the canal over spillways leading to the river approximated 7,350 acre-feet up to September 30, water sometimes having been turned into these spillways nights, and irrigators not being held to strict time schedules. The seepage and evaporation losses in the main canals amounted to 30 per cent of the diversions. The water delivered to irrigators under the Palermo system was carefully measured and sold at the rate of 12½ cents per 24-hour inch. The charge under the South Feather system is $36.50 per inch per year, or about $6 per acre. The charge made by the Oro Water, Light & Power Co. is $5 per acre per year, flat rate. Water is not measured to users under the Sutter-Butte Canal, but is charged for at the flat rate of $2 per acre per year after the payment of a water-right charge of $10 per acre. As much more water is available than is now needed, no attempt is made to require economy by irrigators.

DUTY OF WATER.

The net duty of water was obtained on nine tracts in the Feather River area in 1912, the total amount of land under consideration being 223 acres. The table below summarizes the data obtained. Excepting on the Boalt tract and the tracts on which rice and hops were the irrigated crops, use is believed to represent the average in Feather River Valley. On the Boalt tract use was especially careful. On the tract devoted to hops water was used for starting vines only. Use on the last tract given in the table was low on account of low water. The average duty shown for oranges is 1.27 acre-feet per acre, and for olives is 1.23 acre-feet per acre.

Summary of net duty of water on farms in Feather River Valley, 1912.

Farm.	Source of water.	Crops.	Area irrigated.	Soil.	Total quantity of water used.	Number of irrigations.	Total depth of water applied.
			Acres.		*Acre-feet.*		*Feet.*
E. Stedman	Pump	Prunes	33.0	Sandy loam	24.34	.....	0.75
E. Boalt	Palermo Light & Water Co.	Oranges	26.0	Red loam	24.0	3	.92
Onyett	do	do	10.5	do	17.2	4	1.64
Hess	do	do	11.0	do	19.2	4	1.75
Onyett	do	Olives	10.5	do	17.2	4	1.64
Vanote	Sutter-Butte Canal Co	Alfalfa	18.0	Brown clay loam.	49.0	4	2.72
Peterson	do	Rice	50.0	Adobe	250.0	12	5.00
Eckles	Pump	Hops	54.0	Silt	28.0	1	.52
Block 85	Palermo Light & Water Co.	Olives and peach fillers.	10.0	Red loam	8.0	4	.80
Total			223.0		436.94	.....	1.96

RIPARIAN LANDS.

There is an area approximating 20,000 acres of riparian land along Feather River between Oroville and Marysville, as determined according to instructions to field agents. This area of riparian land is still in large holdings, a number of the original United States patents being still intact. The surface of the land is generally uneven to such an extent as to make leveling necessary before irrigation can be practiced successfully. A fairly good growth of alfalfa and deciduous fruits have been secured on this land without irrigation for a number of years, and very little irrigation development has taken place. The water supply for the riparian land would in many cases need to be pumped from the river. The cost of installing pumps and motors and preparing land for irrigation has seemed rather high to the riparian owners, and large holdings have made intensive farming unnecessary up to the present time. Within the last few years some of the more progressive riparian owners have installed pumps, and over 300 acres are now being irrigated, planted to alfalfa, hops, deciduous fruits, and garden truck. In every instance the owners of this irrigated land are well satisfied with the results obtained and expect to increase their irrigated area as much as possible.

WATER RIGHTS.

Feather River has the largest annual discharge of any single stream in California. Development has not yet reached a point where claims to water for irrigation purposes conflict, and the costly litigation common to other valleys is not found along Feather River. The old mining ditches based their rights on appropriation and use and on notices filed and posted. In every instance the canals built claimed the entire low-water flow. Sutter-Butte Canal Co. made its filing for 2,000 cubic feet per second in 1904. Feather River Canal Co. bases a

claim to 1,200 cubic feet per second on a filing made in 1908. The total filing by these two companies aggregate 3,200 cubic feet per second. The low-water flow of Feather River for 1912 at the points of diversion by these canals has been under 1,000 cubic feet per second. Thus far no provision has been made for storage by these companies. A large number of filings on the water of Feather River and tributaries are to be found in the books of mining and water claims at Oroville, but these show only the intent of some person to divert a certain amount of water and there are no recorded facts to show whether the water filed on has been put to any beneficial use.

SAN JOAQUIN RIVER AND TRIBUTARIES.

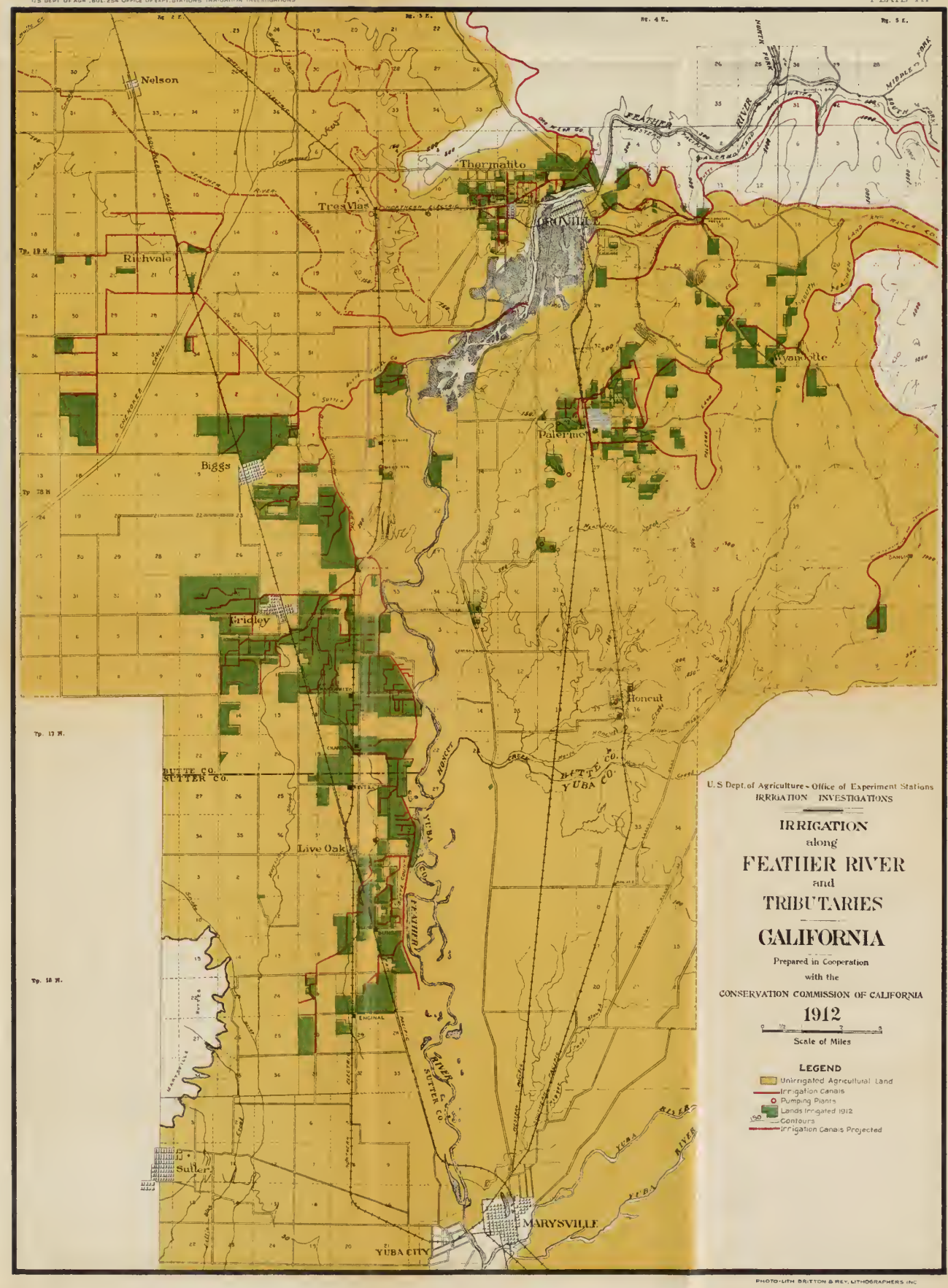
The field work on San Joaquin River and tributaries in 1912 was done by Harry Barnes and Justin T. Kingdon, Mr. Barnes covering diversions from the San Joaquin and all west-side tributaries, and Mr. Kingdon covering diversions from all east-side tributaries, viz, Stanislaus, Tuolumne, Merced, and Fresno Rivers, and Chowchilla Creek. Throughout the sections covered by both agents development by means of pumping plants was noted as well as that by diversions from streams.

SAN JOAQUIN RIVER.

The field report covering the use of water from this stream for irrigation considers development in order down stream from Friant, where San Joaquin River enters the valley floor, to the Patterson pumping plant, inclusive. (Pl. XII.)

The following table lists the canals and pumping plants making diversions, and summarizes the essential data regarding the amount of water diverted and its use in 1912.

PHOTO-LITH. BRITTON & REY, LITHOGRAPHERS, INC.



U. S. Dept. of Agriculture - Office of Experiment Stations
IRRIGATION INVESTIGATIONS

IRRIGATION along FEATHER RIVER and TRIBUTARIES CALIFORNIA

Prepared in Cooperation with the
CONSERVATION COMMISSION OF CALIFORNIA

1912

Scale of Miles

LEGEND

- Unirrigated Agricultural Land
- Irrigation Canals
- Pumping Plants
- Lands Irrigated 1912
- Contours
- Irrigation Canals Projected

PHOTO-LITH BRITTON & REY, LITHOGRAPHERS, INC.

U.S. Dept. of Agriculture – Office of Experiment Stations

IRRIGATION INVESTIGATIONS

IRRIGATION DEVELOPMENT

along

SAN JOAQUIN RIVER

and

PRINCIPAL TRIBUTARIES

CALIFORNIA

Prepared in Cooperation

with the

CONSERVATION COMMISSION OF CALIFORNIA

FRED C. SCOBEY DEL.

1912

Scale of Miles 0 1 2 3 4 5 6

LEGEND

- Grazing Land Flooded from Canals
- Grazing Land Flooded from River
- Lands Irrigated 1912
- Contours (tell Survey)
- Irrigation Canals
- Pumping Plants

SAN JOAQUIN RANCHO

EL PESCADERO

STANISLAUS COUNTY IRRIGATION DISTRICT

MIDDLE STANISLAUS IRRIGATION DISTRICT

SAN JOAQUIN COUNTY IRRIGATION DISTRICT

RANCHO DEL PUERTO

RANCHO ORESTIMBA

RANCHO SANJON DE SANTA R.

MERCED IRRIGATION DISTRICT

MADERA IRRIGATION DISTRICT

SAN JOAQUIN RIVER

STOCKTON

MODESTO

TURLOCK

MERCED

MADERA

FRESNO

Stanislaus River

Tuolumne River

Merced River

Fresno River

San Joaquin River

STANISLAUS COUNTY

SAN JOAQUIN COUNTY

MERCED COUNTY

MADERA COUNTY

FRESNO COUNTY

CALAVERAS COUNTY

TUOLUMNE COUNTY

MARIPOSA COUNTY

Summary of diversions from San Joaquin River between Friant and Patterson, 1912.

Means of diversion.	Areas irrigated, 1912.	Crops irrigated.	Total quantities diverted.	Estimated or measured maximum capacities.	Amounts claimed in notices of appropriation.	Quantities diverted per acre.	Notes.
	Acres.		*Acre-feet.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Acre-feet.*	
Six pumping plants between Friant and Herndon.	342	Alfalfa, 161 acres; vines, 31 acres; deciduous orchards, 150 acres.	333	12	(1)	0.97	Quantity diverted estimated.
Miller & Lux Canals:							
Gravelly Ford	.....	.....	.....	1,500	1,500	.....	Under construction.
Aliso	55,700	Alfalfa, 13,000 acres; grains, 3,700 acres; pasture, 39,000 acres.	137,000	600	500	2.46	High-water canal. Diverted in 1912 from May 10 to June 30 only.
Brown Slough				300	.....		High-water canal. Diverted in 1912 from May 8 to July 5 only. Carried some water to Lone Willow Slough.
Lone Willow Slough.				600	.....		Record of diversion covers Jan. 1 to Sept. 30. Water diverted mostly turned into Columbia and Chowchilla Canals. Between Mar. 13 and Aug. 13 delivered 7,570 acre-feet to California Pastoral & Agricultural Co. for 3,000 acres of alfalfa and 1,500 acres of grain or at rate of 1.68 acre-feet per acre.
Numerous sloughs.							
Heminghaus Slough.	1,200	.....	.....	100	.....	.....	Records of diversion not available.
J. G. James's pump on Fresno Slough.	4,402	Alfalfa, 1,232 acres; grain, 2,561 acres; pasture, 111 acres; other, 498 acres.	2,545	42	.....	.58	Land irrigated also receives water from Kings River through Fresno Slough.
Borland pump on Fresno Slough.	1,300	.....	.....	35	.....	.....	Water used on lands of Miller & Lux.
Helm ditch	1,550	Alfalfa, 950 acres; grain, 600 acres.	1,680	60	.....	1.08	Do.
San Joaquin and Kings River Canal, including Helm Canal and Temple Slough.	163,350	.....	450,047	1,550	[2] 1,200	2.75	Diversion for Temple Slough estimated. Acreage irrigated in 1912 includes 39,600 acres of pasture.
Blythe Canal	8,000	Pasture	24,600	450	1,000	3.08	Water used on lands of California Agricultural & Pastoral Co. Diversions estimated and cover period May 15 to June 23.
East Side Canal	46,500	Alfalfa, 2,250 acres; grain, 1,000 acres; pasture, cropped, 3,705 acres; deciduous orchards, 175 acres; vines, 15 acres; miscellaneous, 4,355 acres; flooded grazing land, 35,000 acres.	75,000	1,000	300	2.05	Accurate measurements not possible under this canal owing to breaks in canal banks and floods. Diversion partly estimated. Water wasted from main canal mostly run over pasture lands.
Patterson pump	6,200	Alfalfa, 4,414 acres; deciduous fruits 389 acres; citrus fruits, 107 acres; grain, 19 acres; orchards and alfalfa, 143 acres; orchards and miscellaneous, 72 acres; other, 774 acres.	12,000	120	300	2.00	Record of amount of water diverted could not be obtained, but estimate given is close approximation.

[1] No filing found.

[2] In two separate notices.

The above table only partially indicates the character of diversions from San Joaquin River for irrigation. The usual floods during May and June, the numerous sloughs into which the channel of the river divides in places, and the poor facilities for gaugings in some of the canals made accuracy of measurements impossible. The season of 1912 being drier and the available water supply consequently less than normal, the amount of water diverted per acre was usually also less. Besides, the area of land flooded in 1912 from canals and from the river was below the area normally receiving water in that way.

Neither Aliso Canal nor Brown Slough is so situated as to receive water when the river is low, their diversions during 1912 being consequently limited. While there is some irrigation of grazing land from Brown Slough, the chief function of this slough is to act as a by-pass to allow more water to enter Lone Willow Slough than the upper part of that slough can carry, part of the increased supply going to Columbia Canal. Most of the water carried by Lone Willow Slough is diverted into Chowchilla and Columbia Canals, from 6 to 10 cubic feet per second carried in Lone Willow Slough being run for stock purposes. Chowchilla Canal is owned jointly by Miller & Lux and the California Pastoral & Agricultural Co. Owing to the various Miller & Lux canals serving large areas owned by one company, segregation of the areas watered by each was not feasible. Water wasted from one canal is often intercepted and distributed by another. During flood periods the numerous high-water channels and sloughs spread additional water over the grazing areas. Conditions are further complicated by additional floods from Fresno River and east-side creeks often covering land under the various canals from the San Joaquin. Normally the area given in the table as watered from these canals may be increased to 70,000 acres.

Land watered by the James pump from Fresno Slough is part of 20,000 acres in Tranquility Colony devoted to diversified farming, the larger quantity of water received being overflow from Kings River into Fresno Slough, which can be carried to the lands of the colony by gravity. Water rights are sold in this section at the rate of 1 cubic foot per second for each 160 acres, with an annual maintenance fee of 60 cents.

Records of diversions by San Joaquin and Kings River Canal, which covers the west side from Firebaugh to Crows Landing, were obtained from San Joaquin & Kings River Canal & Irrigation Co., with frequent checkings of gaugings by the agent of this investigation in order to maintain the same standards throughout the study. Water carried by this company is disposed of to its regular customers, is used on the land of the canal company, or is sold to Miller & Lux. For lands producing one crop annually only, Miller

& Lux pay $1.25 per acre per year, while the established annual rates for general crops are $1.25, $1.75, and $2.25 per acre, respectively, in Fresno, Merced, and Stanislaus Counties. Excess water carried in the canal is used by Miller & Lux for flooding pastures and alkali land, the flooding of the alkali lands being for the purpose of their ultimate reclamation.

Blythe Canal receives water only when the river carries in excess of 2,500 cubic feet per second, but normally the land it serves receives floods and high water from Fresno River and east-side creeks.

East Side Canal is intended to carry water chiefly to Stevinson Colony, but carries water to a considerable area between the headgate and the beginning of the channel maintained by East Side Canal Co. The canal receives floods from Mariposa and Bear Creeks in addition to its diversion from the San Joaquin, and floods pastures between East Side Canal and the river. Irrigators under this canal pay $1 per acre per year and get water on application as long as the supply lasts. Irrigation under the Patterson pump has been begun only within the past few years. As the local company supplying water was unwilling to give out records of the quantities pumped, believing that they did not represent future needs, the best possible estimate of the seasonal diverson was made and each irrigated level was visited to obtain the areas now watered. Water is sold under this enterprise at the rate of $1.50 per acre-foot, with a minimum charge per year of $3.

WATER FILINGS.

The table (see p. 57) lists the water filings of the various interests diverting from the San Joaquin, so far as they can be identified and located as pertaining to diversions being made. Filings covering "all of the river" are not included. Additional filings have been made in 1912 by other interests to the total extent of 8,413 cubic feet per second, mostly for power purposes.

RIPARIAN LANDS.

Even after eliminating claims to water that plainly have never been followed by use, the water filings given in the table are in no way conclusive as to the rights that are claimed. This is because riparian rights are maintained for all of the land bordering the San Joaquin and its various channels and sloughs. An endeavor was made to ascertain the location and extent of these riparian lands, but while sufficient data could be obtained to illustrate clearly the riparian situation and its many complexities, the results of the inquiry are not conclusive as to exact boundaries. Lands are considered riparian that border the river or one of its branches or sloughs, that lie wholly within its watershed, and that have not

been separated from it by grant or subdivision since title passed from the United States, the State, or, in the case of Spanish or Mexican grants, from the Governments of Spain or Mexico. Using this classification as nearly as it could be applied under the conflicting conditions found, the total area of riparian land along the main river from Friant to the north line of Stanislaus County scales to 167,700 acres. An area of 13,584 acres separated from the main San Joaquin has been declared by the courts to be riparian to the river through Fresno Slough into which the San Joaquin backs in periods of high water. Counting this latter area, 14,419 acres are found to be riparian to Fresno Slough north of the southern limits of sections 20, 21, and 22. An additional 3,449 acres separated from the San Joaquin has also been declared to be riparian to it through Fresno Slough, and an additional area of 5,340 acres has been declared riparian to Fresno Slough. A further area of 63,520 acres is found, by the classification adopted, to be riparian to the sloughs of the San Joaquin below Fresno Slough and above the north line of Stanislaus County. Of the total of 254,428 acres of riparian land noted, including that declared by the courts to be riparian, 48,460 acres are cropped irrigated land and 40,720 acres are uncropped and irrigated.

DUTY OF WATER.

Records of the amount of water used in 1912 on 32 separate tracts on the west side of San Joaquin Valley were obtained from San Joaquin & Kings River Canal & Irrigation Co., which keeps accurate account of the water delivered to irrigators. These tracts, which are listed below, together with the essential data relating to them that were obtained, were selected at random, but with the idea of choosing those that would be representative of conditions on the West Side. They vary in area from about 2 acres to 240 acres.

Summary of duty of water on 32 tracts under San Joaquin and Kings River Canal, 1910–1912.

No. of tract.	Vicinity.	Crops.	Area irrigated.	Soil.	Period of record.	Total quantity of water used.	Number of irrigations.	Total depth of water applied.	Method of paying for water used.
						Acre-feet.		*Feet.*	
1	Crows Landing	Alfalfa	49.4	Heavy	Apr. 26 to Aug. 17, 1910	74.74	4	1.59	By quantity.
2	Los Banos	do	30.0	Sandy	May 6 to Sept. 21, 1910	116.6	5	3.88	Do.
3	Gustine	do	56.8	do	May 1 to Aug. 15, 1910	169.4	3	3.09	Do.
4	do	do	131.2	Heavy	Entire season of 1910	158.0	3	1.2	Do.
5	Dos Palos	do	14.6	do	do	19.6	3	1.34	Do.
6	Newman	do	120.0	do	do	205.2	3–5	1.71	Do.
7	Los Banos	do	36.6	do	Apr. 1 to Sept. 15, 1910	47.20	3–5	1.29	Do.
8	Dos Palos	do	21.1	do	May 16 to Aug. 30, 1910	26.12	3–4	1.24	Do.
9	do	do	50.0	do	May 15 to July 15, 1910	76.0	1	1.52	Do.
10	do	do	15.7	do	do	34.2	2	2.18	Do.
11	Newman	do	9.1	do	May 10 to June 15, 1910	9.90	2	1.09	Do.
12	Dos Palos	do	11.44	do	Apr. 28 to Aug. 8, 1911	22.9	4	2.0	By quantity and by acre.
13		do	87.3	do		79.9	4	.92	Do.
14	Los Banos	do	7.4	do	May 13 to Sept. 11, 1911	18.12	2	2.45	Do.
15	Dos Palos	do	14.3	do	May 12 to Aug. 29, 1911	16.72	4	1.27	Do.
16	Los Banos	do	2.3	do	May 20 to Aug. 3, 1911	7.08	3	3.08	Do.
17	do	do	55.1	do	Apr. 24 to Aug. 6, 1911	64.62	3	1.17	Do.
18	do	do	77.2	do	May 4 to Aug. 15, 1911	171.2	3–4	2.22	Do.
19	do	Grass	80.0	Adobe	July 1 to Dec. 27, 1911	296.18	4	3.7	By acre.
20	do	do	240.0	do	do	730.70	4	3.04	Do.
21	do	do	78.8	do	June 30 1911, to May 24, 1912	290.9	5	3.77	Do.
22		do	146.1	Sandy	July 24, 1911, to June 16, 1912	287.9	4	1.97	Do.
23	Dos Palos	Alfalfa	100.0	do	Feb. 14 to May 30, 1912	158.8	3–5	1.59	Do.
24	Los Banos	Grain	15.0	do	Apr. 3 to 28, 1912	33.21	2	2.21	Do.
25	Dos Palos	Barley	40.0	do	Feb. 16 to May 4, 1912	143.5	3	3.59	Do.
26	Los Banos	Alfalfa	223.5	do	July 14, 1911, to May 24, 1912	567.46	4	2.54	Do.
27	Dos Palos	Grass	210.0	Adobe	Oct. 2, 1911, to Apr. 23, 1912	443.7	2	2.11	Do.
28	Los Banos	Alfalfa	160.0	Mixed	July 20, 1911, to June 24, 1912	328.18	4	2.05	Do.
29	do	do	13.7	Heavy	Entire season of 1912	27.7	3	2.02	Do.
30	do	do	48.0	do	do	55.8	2	1.16	Do.
31	do	do	39.6	do	do	33.7	3	.85	Do.
32	do	do	79.0	Light	do	120.7	4	1.52	Do.

WASTE WATER.

In keeping a record of the quantity of water diverted from San Joaquin River it was sought to measure the amount returned to the river unused and therefore presumably wasted. Owing to the fact that most of the water that returned to the river did so only after passing over and irrigating pasture lands, and that the channels through which the return occurred are numerous and in many cases small, measurements were not feasible. Adjacent to both banks of the river are large areas of lowlands, largely subject to overflow during floods and mostly used as pastures. Water wasted from one canal or slough finds its way over the intervening lands to canals or sloughs below, and outside of the periods of floods nearly all of the water diverted is used at least for wetting pastures, even if such use is uneconomical. The water used on the lower lands is held by check levees on the lands and by small dams in the sloughs until it evaporates, sinks into the soil, or percolates back to the river. In order to obtain the best check possible on the quantity that finally returned to the river, records were kept of the flow in the main channel of the San Joaquin immediately above Lone Willow Slough and a few hundred feet below the mouth of Merced River during the time when all of the water of the river was diverted, comprising the periods of May 1 to May 14 and July 14 to September 30. Eliminating the flow of Merced River into the San Joaquin, of 191,600 acre-feet of water diverted below the upper gauging station, 16,070 acre-feet passed the lower gauging station and may be considered as the net return water from irrigation above to Lone Willow Slough. Counting the periods of floods also, out of a total of 725,600 acre-feet that passed the upper station, 282,000 acre-feet ran unused past the lower station.

EAST-SIDE TRIBUTARIES OF SAN JOAQUIN RIVER.

As previously stated, the east-side tributaries of the San Joaquin on which the use of water was studied in 1912 were Fresno River, Chowchilla Creek, and Merced, Tuolumne, and Stanislaus Rivers, these being named here in their order downstream. The large number of canals and pumping plants that use water from or along these streams, and the large area to which the streams are tributary, rendered continuous records on all of them not feasible. For the large systems the records are complete and accurate, except that the presence of vegetation in Crocker-Huffman Canal made satisfactory measurements impossible within reasonable expense. The quantity given in the table as having been diverted by the canal is, however, a close approximation based on careful measurements at various times during the irrigation season. For the smaller ditches on all of the

streams the seasonal flow was estimated after careful inspection or measurement of the channels and of the water available to them.

Summary of diversions of water from east-side tributaries of San Joaquin River, 1912.

Source and means of diversion.	Areas irrigated in 1912.	Crops irrigated.	Maximum flow in 1912.	Quantities diverted.	
				Total.	Per acre.
	Acres.		*Cu. ft. per sec.*	*Acre-ft.*	*Acre-ft.*
Fresno River:					
Madera Canal	10,597	Alfalfa, orchards, and miscellaneous.	[1] 160	28,349	2.68
Hensley ditch	10			[1] 30	[1] 3.00
Huse pumping plant	25	Alfalfa		[1] 50	[1] 2.00
Chowchilla Creek:					
Appling ditch	15		[1] 1,600	[1] 45	[1] 3.00
Sierra Vista ditches	2,375	Mostly vineyard; some grain and pasture.		[1] 3,560	[1] 1.50
Bliss ditches	5,000	Mostly pasture			
Merced River:					
Crocker-Huffman Canal	28,000[2]	Alfalfa, orchards, vines, berries, melons, sweet potatoes, gardens, and pasture.		348,767	[1] 12.45
Kelsey ditch	270	Alfalfa, fruits, and gardens			
Murray Mill ditch	80	do			
Snelling ditch	240	do			
Montgomery & Henderson ditch.	180				
Ruddle ditch	1,000	Alfalfa			
Dale & Cook ditch	700	Alfalfa and pasture		[1] 67,500	
Ferrel & Dean ditch	595				
Means & Montgomery ditch	729.8	Mostly alfalfa			
Feldthaus ditch	336	Alfalfa, grain, and garden			
Merced flour mill ditch	65	Alfalfa and fruits			
Griffith & Shaffer ditch	800	Alfalfa and pasture, 700 acres; gardens, 100 acres.			
Shaffer pumping plant	113	Corn		[1] 226	[1] 2.00
Collier pumping plant	120	Alfalfa and almond orchard		[1] 240	[1] 2.00
Tuolumne River:					
Turlock Canal	96,900	Alfalfa, 56,604 acres; orchards, 6,123 acres; vines, 3,201 acres; potatoes, 2,535 acres; grain, 1,641 acres; melons, 1,250 acres; corn, 5,695 acres; miscellaneous, 1,887 acres; new land, 980 acres.	1,702	253,400	2.52
Modesto Canal	38,247	Alfalfa, 34,383 acres; orchards, 2,703 acres; vines, 1,550 acres; grain, 509 acres; garden, beans, and corn, 632 acres.	737.8	152,033	3.85
La Grange Water & Power Co. ditch.	170			[1] 510	[1] 3.00
Dry Creek (tributary Tuolumne River): Podesta pumping plant.	30	Orchard and garden		[1] 60	[1] 2.00
Stanislaus River:					
Oakdale & South San Joaquin Canal.	3,550	Mostly alfalfa; deciduous orchards and gardens.	125.5	35,111	9.53
Leydecker pumping plant	20	Orchard and garden			
Lund pumping plant	20	Orchard			
Crawford pumping plant	40	Alfalfa and garden		[1] 490	[1] 2.00
Richardson pumping plant	75	Garden			
Patrone pumping plant	90	Orchard and garden			

[1] Estimated.

[2] Estimate of manager of company based on field investigations in fall of 1912. Includes about 3,000 acres of flooded pasture.

FRESNO RIVER.

In the above table Madera Canal is listed as receiving water from Fresno River. It also receives water from Big Creek, a tributary of Merced River, North Fork of San Joaquin River, and Cottonwood Creek. An additional small flow found to be 3.8 cubic feet per second on July 24, and estimated as normally 4 cubic feet per second,

is received from the flume of the Madera Sugar Pine Co., at Madera. Owing to the low discharge of Fresno River, no record of the flow in the canal was maintained after July 24. Water is paid for under this system at the rate of $1.30 per acre for the first irrigation, and 50 cents per acre for each subsequent irrigation, the usual irrigation "heads" being 10 cubic feet per second. Storage to the extent of 5,000 acre-feet has been built, but its use has been enjoined at the instance of lower riparian properties. Pumping from wells supplements the canal supply to a small extent.

CHOWCHILLA CREEK.

Chowchilla Creek is almost wholly a flood-water stream, flowing from about January 1 to June 15 in average years. Its principle branches are Ash and Berenda Sloughs, the former being the main flood channel after it leaves Chowchilla Creek about 10 miles above Minturn, the latter carrying water in times of excessive floods only. A brush dam at the head of Ash Slough and a timber dam provided with gates situated in Chowchilla Creek immediately below Ash Slough regulate the water supply to the four Sierra Vista ditches, as well as to the four Bliss ditches and to the Bliss diversion to pasture lands through the north bank of Ash Slough. The areas irrigated from Chowchilla Creek are more or less indeterminate, depending on the amount of the flood waters. Owing to the intermittent and torrential character of the supply, wasteful methods of irrigation are necessarily followed, much of the irrigation being accomplished merely through the overflowing of ditches during the intermittent high-water periods. In 1912 but little water was used from the Sierra Vista ditches, as the supply did not come when most needed. The supply available to the Bliss ditches came between April 1 and May 30.

MERCED RIVER.

The principal use from Merced River is through Crocker-Huffman Canal (Pl. XIII, fig. 1), this being an old property that has been considerably improved through the construction of a concrete dam across Merced River and enlargements and betterments of the canal channel and structures. Irrigators under this canal pay $20 an acre water-right charge and an annual fee of $2 per acre. In times of flood water is delivered as desired by the irrigators, the surplus as far as possible being used for flooding pasture lands for both irrigation and washing out of alkali. It is estimated that in the irrigation season of 1912 300 cubic feet per second was wasted back into the river during a period of 30 days. No storage is supplied for summer use under this canal. The other

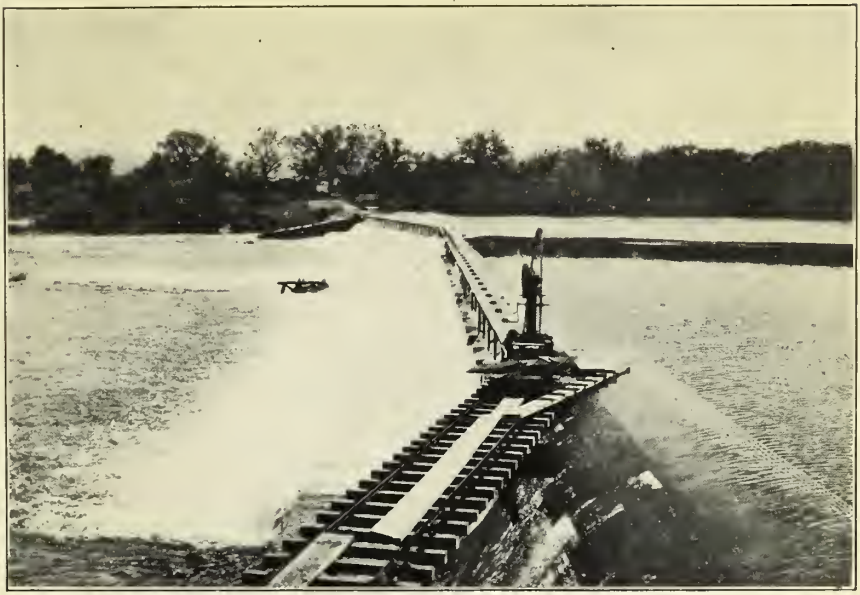


FIG. 1.—CONCRETE DAM IN MERCED RIVER AT HEAD OF CROCKER-HUFFMAN CANAL.

FIG. 2.—MODESTO CANAL PASSING THROUGH THE LOWER FOOTHILLS.

PHOTO-LITH BRITTON & REY, LITHOGRAPHERS, INC.

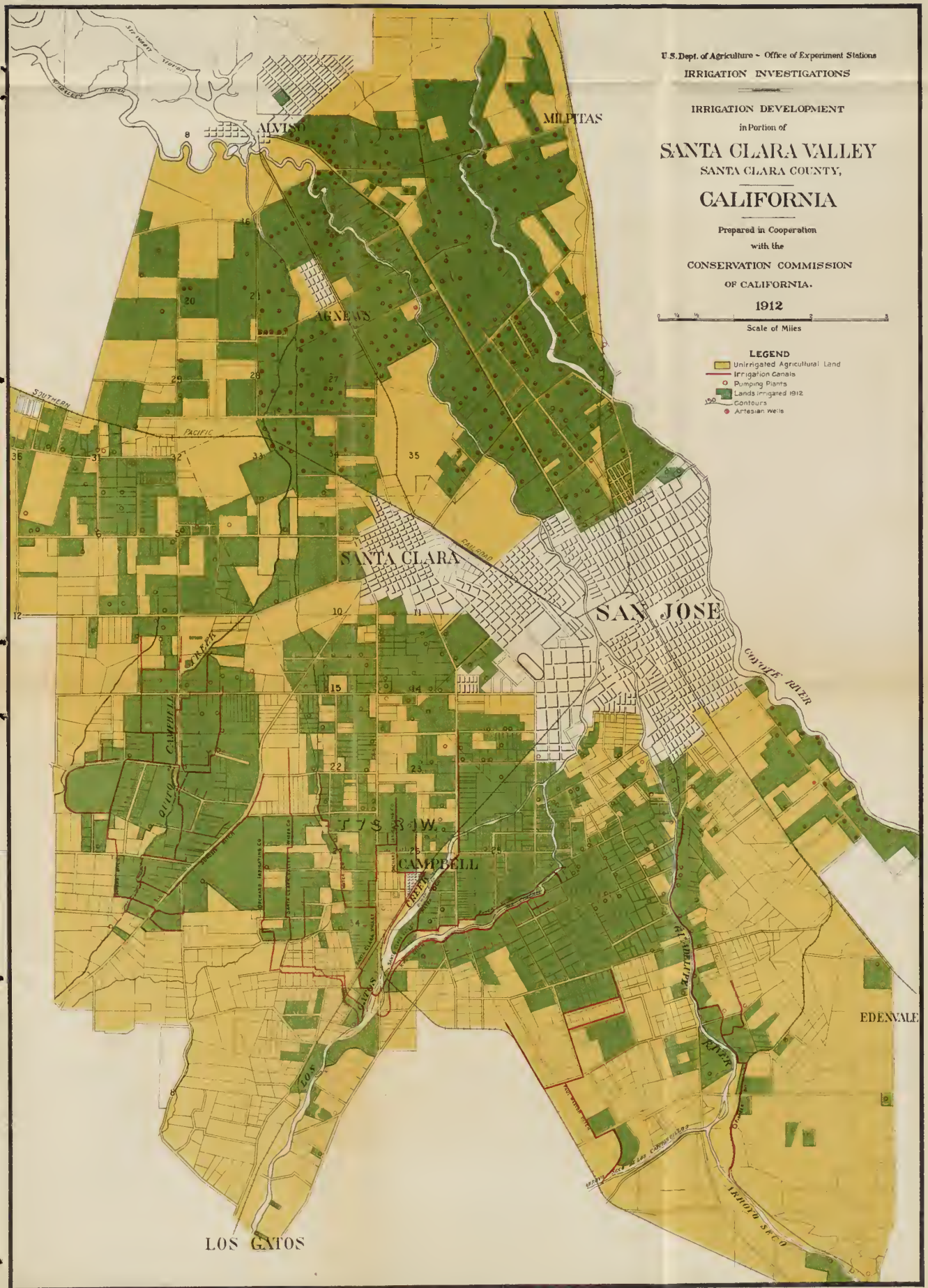


PHOTO-LITH. BRITTON & REY, LITHOGRAPHERS, INC.

ditches leading from Merced River extend along the river between Merced Falls and Livingston. They are all small and water bottom lands that are largely subirrigated and of somewhat indefinite area. Kelsey ditch receives water through a riveted steel pipe through the power dam at Merced Falls; Dale & Cook ditch, by means of a timber crib dam; and Griffith & Shaffer ditch by means of a concrete dam; the other diversions being mainly accomplished by means of temporary dams and brush. Kelsey, Murray Mill, Snelling, Montgomery & Henderson, Ferrel & Dean, Means & Montgomery, and Feldthaus ditches are each owned in partnership by the various irrigators receiving water from them. Crocker-Huffman Canal is a commercial enterprise selling water for profit.

TUOLUMNE RIVER.

The striking feature of irrigation development from Tuolumne River is that of Modesto and Turlock irrigation districts (Pl. XIII, fig. 2), which together embrace 257,353 acres, of which 135,147 acres were irrigated in 1912. The aggregate diversion in 1912 was 405,433 acre-feet, making an average gross use at the rate of 3 acre-feet per acre irrigated. Irrigation began in Turlock district in 1903 and in Modesto district in 1904. In 1904, a year of more plentiful supply, the aggregate diversion by the two districts was 257,640 acre-feet, or about 9 acre-feet per acre irrigated in that year. While considerable areas in both districts are not now receiving surface irrigation, due to the rise in ground-water level, the figures of use in 1904 and 1912 cited here indicate a decided improvement in practice. Both drainage of overirrigated lands and storage for late summer irrigation are in progress in both districts, and an economical use of water is being approached. In 1912, between May 15 and June 15, about 75 cubic feet per second wasted from the ends of the Modesto laterals, and about 150 cubic feet per second wasted from the Turlock laterals. La Grange Water & Power Co. diverts some water above La Grange Dam for power and placer mining purposes and for irrigating the 170 acres listed in the table. On May 3, 1912, the measured flow in this canal was 57.8 cubic feet per second.

STANISLAUS RIVER.

The use of water from the Stanislaus in 1912 is in no way representative of future use, because the principal diversions are to be made by canals of South San Joaquin and Oakdale irrigation districts now under construction. Frequent breaks in structures and weak canal banks resulted in much loss from the old system now being used temporarily. In 1912 the irrigation season extended from April 1 to September 7. Approximately 1,267 acre-feet of the water

diverted by the two districts was wasted into Little John Creek for stock purposes. The Sierra & San Francisco Power Co. uses water for power purposes at Knights Ferry. The five pumping plants listed are within Oakdale irrigation district and will be superseded by the district canals.

IRRIGATION FROM WELLS.

The pumping plants taking water directly from these streams in this territory are listed in the table given above. In addition to the areas covered by these plants 14,950 acres were irrigated in 1912 by pumping from wells. Of this area 9,261 acres were in Madera County, 4,800 acres were in Merced County, and 934 acres were in Stanislaus County and in the portion of San Joaquin County within South San Joaquin irrigation district.

WATER FILINGS.

County records were searched to obtain a list of "live" water filings pertaining to the east side tributaries of the San Joaquin. The filings on behalf of canals and ditches now diverting water for irrigation from these streams were found to be so numerous that it was not practicable to list them in the table summarizing diversions. Madera Canal & Irrigation Co. has made or has succeeded to seven separate filings ranging in amount from 6,000 inches to 345,600 inches, or from 120 to 6,912 cubic feet per second. The Bliss ditches on Chowchilla Creek have a filing of 100 cubic feet per second and the Sierra Vista ditches have one of 200 cubic feet per second. Some of the small ditches on Merced River have filings, but the amounts claimed bear no relation to the amounts diverted. Crocker-Huffman Canal has filings made in 1883 and 1884 of 2,000 and 60,000 cubic feet per second, respectively. For most of the above-named canals court decrees are also relied on for water rights, some of the litigation brought to determine these rights being still pending. Turlock irrigation district has filings of 4,500 and 4,000 cubic feet per second, made in 1889 and 1911, respectively, the latter being for use through storage. Modesto irrigation district has filings of 5,000 and 1,000 cubic feet per second, made in 1889 and 1908. Oakdale and South San Joaquin irrigation districts have made or purchased rights to 21 different filings from Stanislaus and tributary creeks ranging from 70,000 to 1,400 cubic feet per second, the latter amount being called for by the latest filings of each district.

RIPARIAN LANDS.

County and land office records were searched for riparian lands on the east-side tributaries of the San Joaquin as for those on the main San Joaquin. Along the river bottoms and where extensive holdings

border the southern tributaries riparian rights are not important, because the irrigable areas are most largely nonriparian. In the four irrigation districts riparian holdings are watered under the district rights. From the mouth of the Stanislaus to the vicinity of Knights Ferry and not including land at the mouth of the river that is riparian to San Joaquin River, 27,430 acres of riparian land were found, of which 980 acres were irrigated in 1912. Along the Tuolumne, from the mouth of the river to La Grange, the total riparian area noted was 13,675 acres, with 410 acres irrigated in 1912. On the Merced to the east line of township 5 south, range 12 east, the total found was 5,621 acres with 260 acres irrigated, the lands around Snelling not being covered because of unsatisfactory survey records. Over 50,000 acres has been stipulated in litigation as riparian to Merced River, 9,700 acres of which are irrigated, including 9,000 acres of pastures.

SANTA CLARA VALLEY.

The field work in Santa Clara Valley, Santa Clara County, in 1912, was done by R. L. Egenhof. Records were kept of diversions from Campbell and Los Gatos Creeks and from Arroyo Seco and Arroyo Seco de Los Capitancillos. In addition, a new census was taken of irrigation by pumping for the principal portion of the valley. The locations of the ditches, pumping plants, artesian wells, and irrigated areas are indicated in the accompanying map (Pl. XIV). In 1912 but very little water was available in the creeks, the amount that was available coming during or immediately after rainstorms. While there are several old irrigation ditches in Santa Clara Valley, general resort to irrigation has occurred only within the past 10 or 15 years. The normal annual rainfall at San Jose is 15.35 inches. In 5 of the 36 years of record, the precipitation has been under 10 inches, although in 6 years it has been over 20 inches. Except in the wetter years an effort is made to utilize most of the surface flow in the creeks draining from the Santa Cruz Mountains in winter and early spring irrigation (Pl. XV, fig. 1), and it is not uncommon for orchardists to use this surface run-off during rains in order to prevent its being wasted. Much of the surface flow still runs unused to San Francisco Bay, but it is believed that eventually means will be found to utilize much more of it than is utilized at present.

CAMPBELL CREEK.

Sorosis and Lahodie ditches diverted water from Campbell Creek in 1912.

In 1904 there were 3,000 acres irrigated from Sorosis ditch, in 1906 nearly 4,500 acres, and in 1909 about 2,000 acres, while in 1912 the

area was only 200 acres. An additional 32 acres too high to be reached by the ditch was watered by a pumping plant. In 1912 the diversions by Sorosis ditch were: March 6 to March 9, 55.9 acre-feet; March 12 to March 20, 236 acre-feet; April 9 to April 13, 159.1 acre-feet; April 29 to May 4, 42 acre-feet; total, 493 acre-feet. Of the total, 92 acre-feet was delivered to customers for 50 acres and 401 acre-feet, less seepage and percolation losses, was delivered to 150 acres of orchards belonging to the owner of the ditch. The water delivered by Sorosis ditch was distributed by means of flooding basins generally two tree-rows wide and of variable lengths. The gross duty under the ditch was 2.47 acre-feet per acre.

Lahodie ditch had water for only about 5 hours in 1912 and irrigated only 10 acres. Ordinarily about 100 acres are irrigated.

LOS GATOS CREEK.

Los Gatos Creek furnishes water for Kirk Ditch Co., Santa Clara Water Co., and Orchard Irrigating Co.

Kirk Ditch Co. is an association of 25 farmers who operate Kirk ditch. This ditch was built in 1857 and 1858, has a maximum capacity of about 40 cubic feet per second, and usually covers about 1,000 acres of land. In 1912, 412 acres were irrigated with 950 acre-feet of water, 679 acre-feet being diverted between March 8 and March 27, 219 acre-feet between April 11 and April 19, and 52 acre-feet on April 29 and 30. The quantity diverted per acre was therefore 2.3 acre-feet. Estimating a total seepage loss of 30 per cent, the net duty was about 1.60 acre-feet per acre. All of the water was applied by flooding, as much as 8 cubic feet per second often being used in a single head. Most of the land irrigated was in orchards. Some of the land under Kirk ditch was watered from wells. The cost of water under the ditch in 1912 was only 35 cents per acre for assessments. In 1911 assessments were only 10 cents per acre. When built Kirk ditch covered the land of 6 riparian owners. The same land is now under the ditch but in 25 smaller holdings.

Santa Clara Valley Water Co. controls Statler and Duncan ditches from Los Gatos Creek and a third ditch on the west side. In 1912 Statler ditch received water for less than 2 days with a maximum flow of 35 cubic feet per second, 50 acres being irrigated. The flow in Duncan ditch lasted only 3 days, and 100 acres were irrigated. Practically no water was received by the west side ditch. Santa Clara Valley Water Co. sells water at the rate of 50 cents per hour for 3 cubic feet per second up to May 1, with a 50 per cent increase thereafter. The ditches of the company cover about 3,000 acres, but no more than 1,500 acres are irrigated in any one year. The area served is entirely in orchards and mostly in tracts of 10 to 30 acres.

The two remaining ditches from Los Gatos Creek are those of the Orchard Irrigating Co. There are about 3,000 acres under these ditches of which about 300 acres were irrigated in 1909, and only about 20 acres in 1912. Water is sold under this ditch at the rate of 75 cents per hour for 2.5 cubic feet per second.

ARROYO SECO DE LOS CAPITANCILLOS.

Masson ditch diverts water from this stream to 308 acres of riparian land and other lands. About 5,000 acres could be covered by this ditch but in 1912 only 116 acres were irrigated. The total diversion was 460 acre-feet, taken out between March 6 and April 2 and between April 9 and May 10, a slight subsequent flow being turned into a vineyard. Measurements showed that 50 to 75 per cent of the water diverted was lost through seepage from the ditch. The basin method of irrigation was used. This stream normally waters about 800 acres.

ARROYO SECO.

The water of Arroyo Seco is diverted by Pioneer ditch, which is owned cooperatively by farmers on the east side of Arroyo Seco and Guadalupe River. The water supply of Arroyo Seco is more steady than that of Los Gatos or Campbell Creeks, yet at times during 1912 from 25 to 60 per cent of the water available at the head of Pioneer ditch was wasting through the temporary dam in Arroyo Seco. Heavy losses from the ditch were also found, reaching in individual instances as high as 80 per cent of the amount turned down to the farmers. A total of 878 acre-feet of water was diverted by Pioneer ditch and the total area irrigated was a little less than 200 acres, making a gross duty of about 4.39 acre-feet per acre. It was estimated that not over 300 acre-feet of the 878 acre-feet diverted was actually used in irrigation. The farmers under Pioneer ditch pay 60 cents per hour for water in March, 80 cents per hour in April and May, and $1.50 per hour in June. The heads delivered are not uniform and night prices are one-half those charged for the day.

IRRIGATION FROM WELLS.

Several hundred pumping plants are now drawing water from wells for irrigation in Santa Clara Valley, these being indicated on the map previously referred to. Fifteen of these plants were under observation in 1912 for the purpose of ascertaining the depths from which water is being lifted, the costs of pumping, and the kinds of power being used, these facts illustrating the character of irrigation with underground waters in this valley. Most of the older plants are operated by steam but the greater number of plants are gasoline-operated, with new installations largely electric. The lifts with the

15 plants under observation varied from 12 feet to 125 feet, with about one-half from 70 feet to 85 feet. The costs of raising 1 acre-foot of water 1 foot high varied from 5.4 cents to 8.2 cents for the steam plants, not counting 1 plant in very bad condition; from 4 cents to 8.4 cents for the gasoline plants; and from 9.6 to 12.4 cents for the electric plants. The actual costs per acre-foot of water lifted varied from $1.48 in the case of a 20-foot lift to $10.75 in the case of a 112-foot lift, with about one-half being from $4.92 to $8.33. Many orchardists do not have their own pumping plants but purchase pumped water, sometimes at a cost of as much as $20 per acre-foot. These figures indicate something of the loss involved in the wasting of from 25 to 80 per cent of the creek water in this valley, as found in some of the cases that have been cited.

WATER FILINGS.

The water filings records of Santa Clara County were searched for claims covering the use of water from ditches under observation in 1912. Filings were noted for Masson ditch and for Orchard and Statler ditch companies. The amounts claimed vary from 10 to 200 cubic feet per second, but as the diversions in 1912 were below normal no comparisons of value can be made.

RIPARIAN LANDS.

The usual investigation regarding riparian lands was made on the streams of Santa Clara Valley included in the investigation, and the usual difficulties were found. The best estimate possible shows 1,600 acres of riparian land along Campbell Creek between Saratoga and the Homestead road, with 1,100 acres of this usually irrigated. The channel of Los Gatos Creek has changed from time to time and the questions of riparian ownership growing out of that fact rendered a satisfactory determination of the limits of riparian land impracticable. About 700 acres of riparian land was found along Arroyo Seco de Los Capitancillos, of which about 200 acres are usually irrigated, with only 45 acres irrigated in 1912. Between Hacienda and the junction of Arroyo Seco and Arroyo Seco de Los Capitancillos there are approximately 1,500 acres riparian, with less than 100 acres irrigated. Between the junction of these two creeks and San Jose about 1,200 acres are riparian to Guadalupe Creek, 750 acres of this usually being irrigated and 400 acres being irrigated in 1912. Riparian rights on Los Gatos and Guadalupe Creeks have mostly been purchased by a local company supplying water to San Jose. Under one ditch in the valley one-half the usual irrigation rates are charged riparian proprietors.

SANTA CLARA RIVER.

The field work on this stream in 1912 was done by Mr. J. N. Irving, under the direction of Mr. C. E. Tait. All diversions from Santa Clara River and its three principal tributaries, Piru, Sespe, and Santa Paula Creeks, were made in Ventura County. (Pl. XVI.) The valley watered by these diversions is one of the important southern coastal areas, but it presents different conditions from those found in the coastal valleys farther south. The largest irrigated acreages are in deciduous fruits and beans rather than in citrus fruits, as in Los Angeles, Riverside, and San Bernardino Counties, although citrus fruits are the third irrigated crop in point of area.

The following table lists the ditches making diversions in 1912 and summarizes some of the principal data gathered regarding them.

Summary of diversions and use of water from Santa Clara River, 1912.

Canal or company.	Source.	Area irrigated.	Crops irrigated.	Total quantities diverted to Oct. 31.[1]	Maximum diversions noted.	Amounts of water claimed in notices of appropriation.	Quantities diverted per acre.	Estimated losses.	Remarks.
		Acres.		*Acre-feet.*	*Cubic feet per second.*	*Cubic feet per second.*	*Acre-feet.*	*Per cent.*	
Camulos	Santa Clara River	400	Alfalfa, 150 acres; deciduous fruits, 190 acres; citrus fruits, 60 acres.	1,707	10.2	(2)	4.27	20	Claims riparian right and use since about 1860.
Hardgrave & Comfort	Piru Creek	470	Alfalfa, 115 acres; citrus fruits, 5 acres; miscellaneous, 350 acres.	2,583	14.4	(2)	5.50	25	
Piru Water Co	do	376	Deciduous fruits, 160 acres; citrus fruits, 216 acres.	1,419	5.2	Up to 40	3.77	10	
South Side Improvement Co	Santa Clara River	1,400	Deciduous fruits, 700 acres; citrus fruits, 700 acres.	1,061	.....	20	.76	10	Record obtained from company and did not give maximum diversions.
Stringtown & Carmicle	do	350	Alfalfa	2,054	(3)	(2)	5.87	20	
Sespe Land & Water Co	do	40	do	603	5.0	20	15.10	20	
Fillmore Irrigation Co	Sespe Creek	1,674	Alfalfa, 58 acres; deciduous fruits, 119 acres; citrus fruits, 1,497 acres.	3,328	14.4	.....	2.00	15	Purchased right for 750 inches based on 3 filings of Sespe Land & Water Co.
Atmore	do	150	Alfalfa, 110 acres; deciduous fruits, 25 acres; citrus fruits, 15 acres.	698	.....	40	4.65	20	No daily record practicable, but seasonal flow estimated.
Hardison Ranch Co	Canyon	109	Alfalfa, 2 acres; citrus fruits, 90 acres; vineyard, 2 acres; miscellaneous, 15 acres.	151	.6	.....	1.39	5	Has filings for 100 inches and 25 inches.
Interurban Land & Water Co. (Carmicle ditch).	Santa Clara River	1,112	Alfalfa, 350 acres; deciduous fruits, 380 acres; citrus fruits, 354 acres; beans, 28 acres.	1,487	9.54	12	1.34	20	Weeds in ditch made satisfactory record of diversions impossible.
Turner ditch	do	187	Alfalfa, 12 acres; deciduous fruits, 62 acres; citrus fruits, 74 acres; beans, 37 acres; miscellaneous, 2 acres.	1,492	7.8	(2)	7.98	30	Only about 400 acre-feet used, the balance being returned to river.
Santa Clara Water & Irrigation Co. (Farmers ditch).	do	1,734	Alfalfa, 40 acres; deciduous and citrus fruits, 348 acres; beans, 896 acres; miscellaneous, 116 acres; not reported, 334 acres.	4,699	23.0	(2)	2.70	50	

FIG. 1.—SPRING IRRIGATION FROM FLOODS IN CREEKS, SANTA CLARA VALLEY, SANTA CLARA COUNTY.

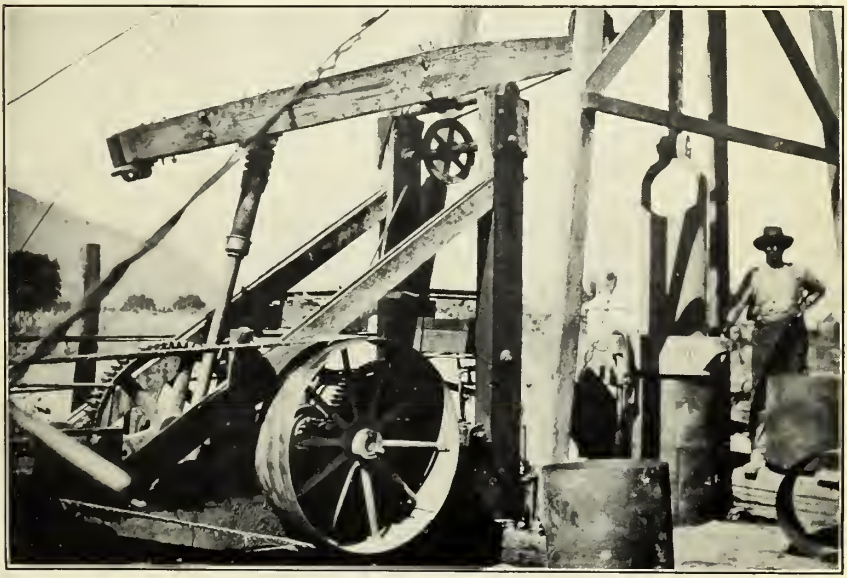
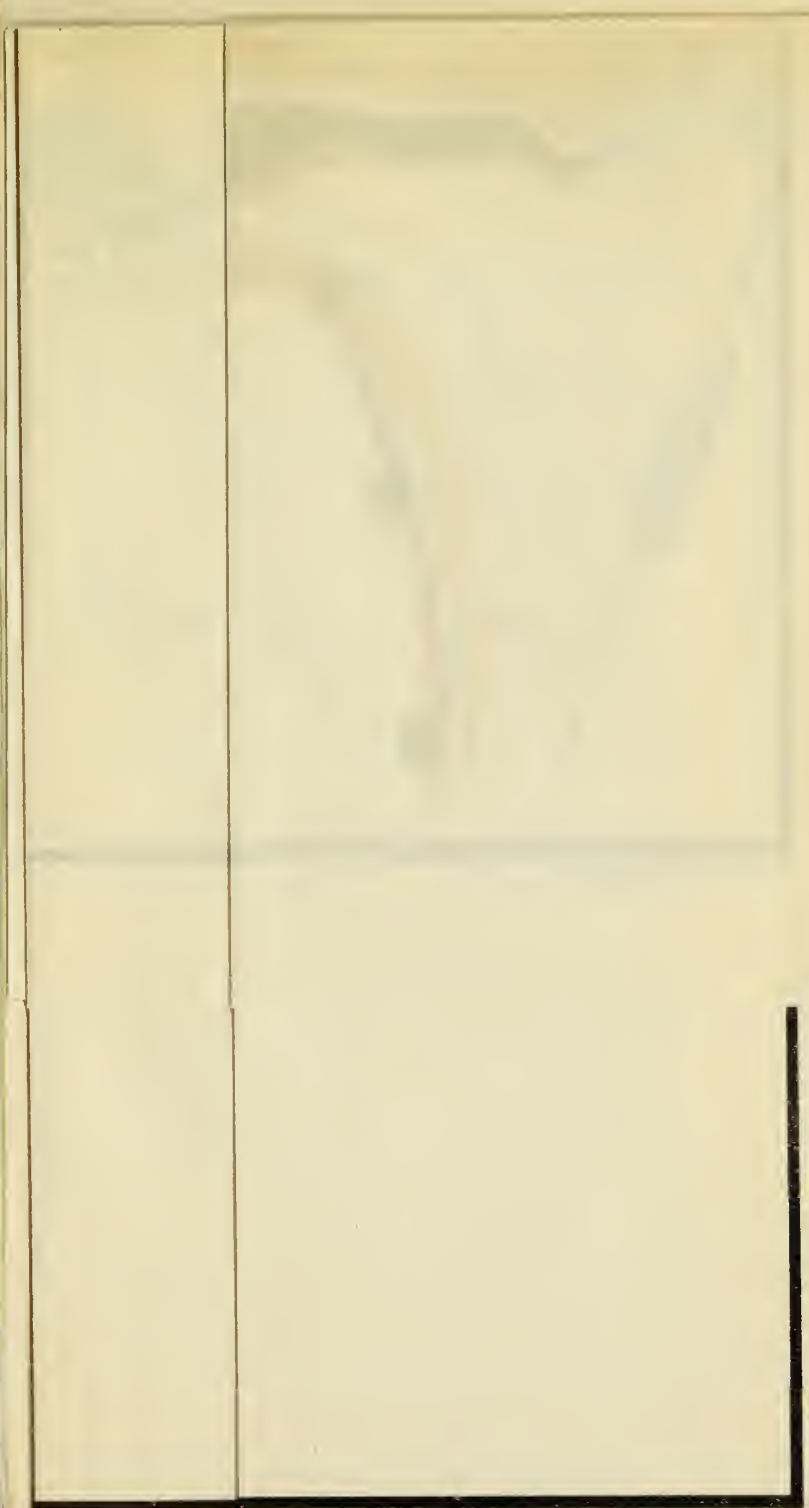


FIG. 2.—BORING A 24-INCH WELL FOR IRRIGATION WATER IN SAN DIMAS WASH, SOUTHERN CALIFORNIA.



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U.S. Dept. of Agriculture ~ Office of Experiment Stations

IRRIGATION INVESTIGATIONS

IRRIGATION DEVELOPMENT

along

SANTA CLARA RIVER

VENTURA COUNTY

CALIFORNIA

Prepared in Cooperation

with the

CONSERVATION COMMISSION

OF CALIFORNIA.

1912

Scale of Miles

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Interurban Land & Water Co. (River Street ditch).	.....do.....	1,536	Alfalfa, 200 acres; deciduous fruits, 1,266 acres; citrus fruits, 20 acres; beans, 50 acres.	3,540	20.0	(2)	2.32	30
Santa Paula Water Works....	Santa Paula Creek....	1,628	Deciduous fruits, 880 acres; citrus fruits, 748 acres.	1,772	9.0	(2)	1.89	10
Santa Clara Water & Irrigation Co. (Saticoy division).	.....do.....	4,414	Alfalfa, 173 acres; deciduous fruits, 374 acres; citrus fruits, 155 acres; beans, 3,601 acres; miscellaneous, 111 acres.	6,282	38.1	(2)	1.42	30

[1] Diversions estimated for some ditches for September and for all ditches for October.

[2] No filings found.

[3] Stringtown ditch, 4.7; Carmicle ditch, 8.2.

For the purpose of gathering the data summarized in the above table, gauge rods were set at the head of each ditch, except in two cases where it was not possible to find observers convenient to the gauge rods. Daily observations were begun in April and continued through September, with the exception of one or two ditches, and the October records were all estimated on the basis of the knowledge gained through the season's work prior to that month. Due to most of the ditches becoming foul with weeds, moss, and sand, it was necessary to alter the rating curves as the season advanced. Even with this precaution some of the figures are only approximately correct. They do, however, show the general character of diversions on this stream with sufficient accuracy for the purposes of this report. The estimated seepage losses are based on observation and inquiry and are necessarily only approximate.

CAMULOS DITCH.

The water diverted by this ditch is used on the Camulos rancho of 400 acres, all said to be riparian land. No record is kept by the owners of the ditch as to the amount of water diverted or the amount of water applied. The ditch is about 2½ miles long, 1 to 2 feet deep, and 4 to 5 feet wide. The record of diversions was begun on May 20.

HARDGRAVE & COMFORT DITCH.

Water from this ditch is used in rotation by the owners, each owner being entitled to a certain number of days' run each month. No record is kept of either diversions or use. The ditch is about 3 miles long, 4 feet wide, and 1 to 2 feet deep. The record of diversions was begun on May 2.

PIRU WATER CO.

The water diverted by this company is carried in a pipe line from Piru Creek and distributed in branch pipe lines, resulting in very little loss. No attempt is made to measure the water diverted or delivered, but each user has the entire flow in accordance with his acreage. The record of diversions was begun on May 17. The Piru Water Co. pipe line and the Hardgrave & Comfort ditch together divert all the water from Piru Creek during the summer months.

SOUTH SIDE IMPROVEMENT CO.

The diversions given for this ditch were obtained from the records of the company, because it was not convenient to take daily gauge readings. A charge of 60 cents per 100 miner's inches per hour is made by this company to pay the maintenance charges.

STRINGTOWN AND CARMICLE DITCHES.

These two ditches together irrigate 350 acres owned by three farmers, water from them being used in rotation, with no record of it kept. The ditches are each about 2 miles long. The record of diversions by Carmicle ditch was started on June 12 and by Stringtown ditch on May 14.

SESPE LAND & WATER CO.

Water diverted by this company is taken from a slough rising on the north side of Santa Clara River about 2 miles east of Fillmore. About 350 acres can be irrigated from the ditch, but at present the water is applied to only about 40. The ditch is small and quickly becomes filled with weeds. In 1912 water was applied to the land about 12 days each month, the average use being about 3 cubic feet per second. The ditch is about 1.5 miles long, 2.5 feet wide, and 1.5 feet deep. The seasonal record of diversions by this company was started on June 11.

FILLMORE IRRIGATION CO.

All of the water of Sespe Creek is diverted by this company during the summer months, the creek becoming dry by the middle of July in 1912. No records of diversions are kept by the company, but those obtained by this office in 1912 were started on May 8. The main ditch of the Fillmore Irrigation Co. is about 5 miles long, 4 to 5 feet wide, and 1 to 2 feet deep.

ATMORE DITCH.

Water from this ditch is used by Sespe rancho and three other owners. No record was feasible on this stream in 1912 owing to the distance to gauge readers, but the flow was estimated from frequent measurements.

HARDISON RANCH AND WARING DITCHES.

These are two small ditches that take water from canyons on the north side of the river. The former carries from 0.4 to 0.6 cubic foot per second, while in the spring the latter carries about 0.8 cubic foot per second, with the supply gradually diminishing until it disappears, from the 1st to the 15th of June.

INTERURBAN LAND & WATER CO., CARMICLE DITCH.

Water is diverted from Santa Clara River into this ditch to irrigate about 300 acres of alfalfa, and then to supply water for a pumping plant irrigating about 800 acres of fruit land. The record of diver-

sions given in the table is not of much value, because more water than is used is diverted and later returned to the river below the pumping plant. No attempt is made by the company to measure the water diverted or used on the alfalfa, but all of the water pumped is measured, because it is sold at from 30 cents to 40 cents per inch for 24 hours. In 1911, 452.9 acre-feet were pumped to 711 acres of orchard, giving a depth of 0.64 foot. The complete record of pumped water for 1912 is not available. While the maximum amount of water diverted by the ditch was found to be 9.54 cubic feet per second, the best estimate of the average diversion gives 4.5 cubic feet per second. The record for 1912 began on May 18.

TURNER DITCH.

Water from this ditch is used by six irrigators, who together maintain it. No records of diversions or use are kept. It is estimated that only about 400 acre-feet of the quantity diverted was utilized in 1912, the surplus having been returned to the river at the end of the ditch. Water has been used from this ditch for 30 or 40 years. The record in 1912 was started on May 16.

SANTA CLARA WATER & IRRIGATION CO., FARMERS DITCH.

Water is sold from this ditch at from 5 to 15 cents per 24-hour inch. No record is kept of the water diverted, but an accurate record is kept of that sold. The observations in 1912 began on May 29.

INTERURBAN LAND & WATER CO., RIVER STREET DITCH.

Water is diverted by this ditch to supply about 1,500 acres, but whether this land is irrigated depends entirely on rainfall. Water is, however, kept in the ditch continuously, and when not used is returned to the river above the next diversion. The quantity thus disposed of in 1912 to the end of August was 313 acre-feet, and on August 27 it was estimated that during the remainder of the season about twice as much water would be sold unless rendered unnecessary by early rains. The water sold between May, 1911, and March, 1912, amounted to 827 acre-feet, but that season was unusually long.

SANTA PAULA WATERWORKS.

Water is taken by this company from Santa Paula Creek by means of a concrete dam and concrete gravity pipe line. Water is furnished to the Thermal Belt Pipe-Line, to the city of Santa Paula, and to 125 acres of citrus trees in the vicinity of Santa Paula. The observations in 1912 began on May 16.

SANTA CLARA WATER & IRRIGATION CO., SATICOY DIVISION.

Observations on this ditch in 1912 began on May 22. In addition to the record of diversions from the river, an account of the water sold was obtained from the company. The first use was on May 22. From May 31 to August 12 it was continued without interruption, the quantities sold varying from 337 to 1,141 miner's inches in June, from 949 to 1,656 inches in July, and from 470 to 1,120 inches between August 1 and August 12. On August 12 it was estimated that about an average of 150 miner's inches would be sold daily until the rains should begin. The diversion by this ditch is the lowest on Santa Clara River.

IRRIGATION BY PUMPING PLANTS.

Besides the land irrigated from ditches and pumping plants diverting water from Santa Clara River and tributaries, a total of 8,937 acres is irrigated from wells varying in depth from about 100 feet to about 500 feet, some of the pumping plants having been installed during 1912. The valley seems to have water-bearing strata underlying it from the coast at least up to Piru, where the last large plant is situated. Above that point in the valley, however, underground water is obtained by windmills. In most cases gasoline engines and electric motors furnish the motive power for the pumps, but steam is used in a few plants. The water from these pumping plants costs the users 20 cents to 40 cents per 24-hour inch. The table below shows the quantity of water pumped and the acreages irrigated by six typical plants of the valley. It is to be noted that the average depth on 2,471 acres was 0.55 feet.

Summary of irrigation by six typical pumping plants in Santa Clara River Valley in 1912.

Name of plant.	Acreage irrigated.			Total quantity of water pumped.	Depth of water applied
	Walnuts.	Beans.	Citrus fruits.		
				Acre-feet.	*Feet.*
Montalvo Irrigation Co	.....	126	.....	160	1.27
Saticoy Water Co	350	30	.....	178	.47
Saticoy Irrigation Co	325	35	40	222	.55
Mound Water Co	200	214	786	550	.46
Saticoy Citrus Co	18	282	.....	214	.71
Todd	.....	65	.....	32	.49
Total	893	752	826	1,356	.55

DUTY OF WATER UNDER DITCHES.

During the season of 1912 records were obtained showing the amount of water used on a number of typical farms for the principal crops irrigated in Santa Clara River Valley, some of the records per-

taining to the season of 1911. Giving the various fields equal weight in averaging, since they are typical, the average depths of water applied to the various crops were as follows:

Crops.	Feet.	Crops	Feet.
Alfalfa	6.21	Beans	0.46
Walnuts	.97	Lemons	2.74
Apricots	1.02	Oranges	2.48
Corn	2.21		

As a rule, alfalfa was watered twice between cuttings, citrus fruits once every 4 to 6 weeks, walnuts and apricots twice during the season, and beans usually but once. Near the coast some of the beans and walnuts are not irrigated at all. These crops, as well as apricots, can be grown without irrigation anywhere along Santa Clara River in Ventura County where the soil is suitable, but a better crop is obtained where water is used. About two-thirds of the irrigated acreage is in beans and deciduous fruits, which according to the table above receive the least quantities of water. In the irrigation of alfalfa the land is flooded by means of ditches and portable galvanized-iron pipe. For all other crops the furrow system is used, the water being carried to the furrows either in open head ditches, through the sides of which short 1 to 2 inch pipes are led to the furrows, or in buried cement pipes with hydrants at each tree row. Water is applied to the land quickly, not being held in one furrow more than 36 hours and in some cases as short a time as 12 hours.

WASTE OF WATER.

Considerable difference is to be noted between the amounts of water diverted per acre and the amounts of water received by the land, as indicated by the figures on duty of water. The amount of water represented by this difference is not all wasted, much of it being returned to the river at such places as to enable it to be diverted by the next ditches below. The water supply in general being abundant for the present acreage, it is not conserved as it should be, so that a large percentage is lost in seepage from the ditches. In no case during the season of 1912, however, was willful waste of water noted. As the demand for water increases a considerable supply can be provided by preventing present waste.

WATER FILINGS.

The table given on page 72 indicates the amounts of water claimed on behalf of each ditch so far as filings could be located in the records. Note was made of only such filings as are known to refer to water now

being used, except that a record was made of all filings made in 1912. A filing of 1874 calling for 60 "square" inches under a 4-inch pressure was found, the water called for now being used by Waring ditch. One was found dated 1905 that calls for 300 inches from Santa Clara River to be used on the Sespe rancho. One dated 1904 calls for the same quantity for the Sudden ranch. The Mound Water Co. has a filing upon the underground water of Santa Clara River calling for 2,000 inches, the date of the filing being 1904. In addition Saticoy Irrigation Co. and Saticoy Development Co. have made filings for 100 and 500 inches, respectively, of artesian flow in the town of Saticoy, the dates of the filings both being 1904.

Besides searching the records of Ventura County, those for Los Angeles County were looked into for filings on Santa Clara River made in 1912. Seven were found ranging from 5 to 5,000 inches. In making these filings the usual miscellaneous purposes of proposed use were given, as placer mining, power, irrigation, domestic use, etc.

RIPARIAN LANDS.

The usual attempt was made in Santa Clara River Valley to learn something of the conditions of riparian ownership. Riparian land constitutes a narrow strip along the river, except where larger Spanish grants bordering the river are still intact. The total area of irrigated riparian land found according to the usual standards was 6,477 acres, of which 4,282 acres was under ditches and 2,195 acres was served by pumping plants from wells. The following tabular summary indicates something of the importance of riparian lands in this section by showing the percentage of water diverted that was applied to such lands under the various ditches, as well as under the private pumping plants taking water from wells:

Percentage of water applied to riparian land to Aug. 31, 1912.

Canal or company	Percentage.
Camulos	100
Hardgrave & Comfort	67
Piru Water Co	11
South Side Improvement Co	0
Stringtown and Carmicle	100
Sespe Land & Water Co	0
Fillmore Irrigation Co	22
Atmore	66
Hardison Ranch Co	0
Interurban Land & Water Co. (Carmicle ditch)	72
Turner	50
Santa Clara Water & Irrigation Co. (Farmers ditch)	2
Interurban Land & Water Co. (River Street ditch)	43
Santa Paula Water Works	0
Santa Clara Water & Irrigation Co. (Saticoy division)	32
Private pumping plants from wells	100

SUMMARY.

In general water is diverted from Santa Clara River and tributaries by temporary dams built annually. No record is kept by any of the water users of the amount of water diverted, and except where water is charged for no record is kept by users as to the amount of water applied to the land. The gross amount of water diverted per acre from May or June to the end of October, with the diversions for October estimated, range from 0.76 to 7.98 acre-feet per acre. The estimated seepage losses in the distributing systems range from 5 to 30 per cent. The average duty of water under pumping plants serving 2,471 acres was 0.55 acre-foot per acre. The average duty found under canals ranged from 0.46 acre-foot per acre for beans to 6.21 acre-feet per acre for alfalfa, with the average duty for lemons and oranges 2.74 and 2.48 acre-feet per acre, respectively. No difficulties seem to have arisen in the distribution of water, as the supply has thus far seemed to be ample, because irrigation is an aid to agriculture rather than an absolute necessity. When the remaining irrigable land is developed it is plain that water rights will need to be more closely defined than at present and accurate record of all diversions kept.

SANTA ANA RIVER.

Field work on this stream in 1912 was done by Mr. A. J. Salisbury, jr., under the direction of Mr. C. E. Tait. The land irrigated from Santa Ana River is naturally divided into seven irrigation areas. (Pl. XVII.) The following table lists the ditches taking water from the Santa Ana and its tributaries, grouped according to these seven areas, and summarizes the principal data gathered in 1912:

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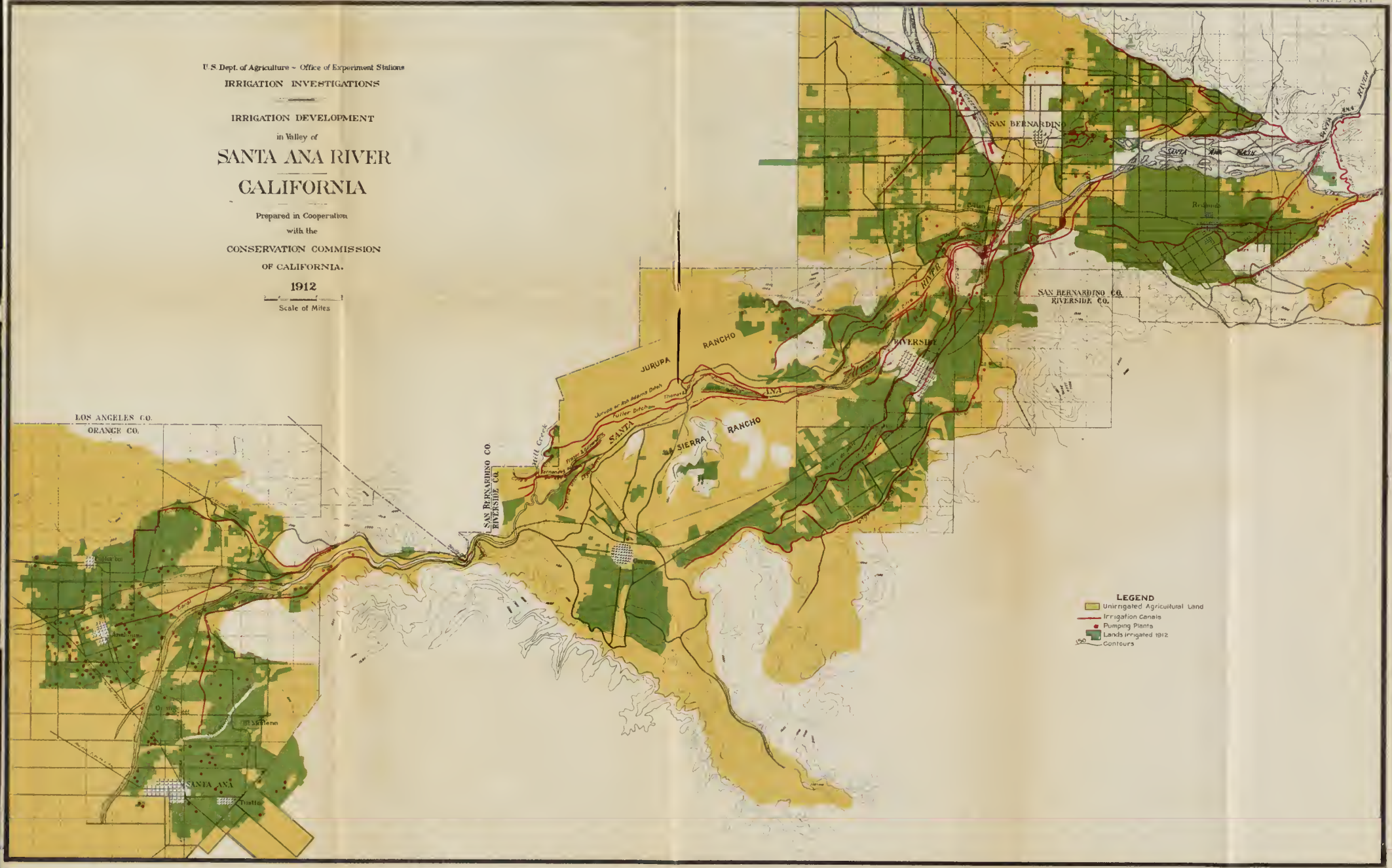

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Summary of measured or estimated diversions of water from Santa Ana River and tributaries, January to November, 1912.

System.	Source.	Area irrigated.	Crops irrigated.	Total quantities diverted and used.	Maximum diversions noted.	Quantities diverted per acre.	Remarks.
		Acres.		*Acre-feet.*	*Cubic feet per second.*	*Acre-feet.*	
Redlands-Highlands area:							
Old Town	Mill Creek	2,700	Citrus fruits	6,604		2.45	An additional 6,945 acres are irrigated in this area from small mountain streams and wells, of which 2,680 acres are in citrus fruits, 2,465 acres in alfalfa, and 1,800 acres in miscellaneous crops.
Crafton Water Co	do	1,800	do	4,379		2.43	
Bear Valley Mutual Water Co	Santa Ana River	15,000	do	30,070	100.00	2.00	
City Creek Water Co	City Creek	320	do	678	9.57	[1] 2.11	
San Bernardino Basin:							
McKenzie ditch	Warm Creek	432	Alfalfa and truck	884		[1] 2.04	Irrigated crops distributed as follows: Citrus fruits, 255 acres; alfalfa, 2,072 acres; miscellaneous, 850 acres.
Shay ditch	do	175	do	650		3.71	
Warm Creek	do	200	Mostly alfalfa	[2] 1,291		[2] 6.45	
Rialto-Colton area:							
Fontana Development Co. and others.	Lytle Creek and wells.	15,000	Citrus fruits, 12,800 acres; alfalfa, 800 acres; miscellaneous, 1,400 acres.	[4] 19,607		1.31	
Meeks & Daly ditch	Warm Creek		Citrus fruits and alfalfa	6,850	16.50		
Riverside area:							
Riverside Water Co	Warm Creek and artesian wells.	9,000	Citrus fruits, 4,500 acres; alfalfa, 3,900 acres; miscellaneous, 258 acres; other, 342 acres.	26,170	67.00	2.91	Additional areas are irrigated in this division as follows: Riverside Land & Irrigating Co., 1,400 acres alfalfa and 360 acres miscellaneous; North Riverside and Jurupa, 2,794 acres citrus fruits, 1,035 acres alfalfa, 283 acres miscellaneous; Riverside-Highlands, 2,300 acres citrus fruits; pumping plants, 680 acres citrus fruits, 240 acres alfalfa, and 850 acres miscellaneous.
Jurupa	Santa Ana River	785	Citrus fruits, 120 acres; alfalfa, 465 acres; miscellaneous, 200 acres.	2,324		[6] 2.96	
Gage Canal Co	do.[6]	9,040	Citrus fruits	[7] 16,560		[7] 1.83	
Alvitrez ditch	Spring, brook, and wells.	800	Alfalfa and truck	[8] 2,744		3.43	
Santa Ana River area:							
Lower Legage ditch	Santa Ana River	150	Mainly alfalfa	602		4.01	Diversions under these ditches estimated on the basis of numerous measurements. Of 1,259 acres irrigated in Santa Ana River bottoms in 1912, 250 acres are in citrus fruits, 910 acres in alfalfa, and 99 acres in miscellaneous crops.
Upper Legage ditch	do	75	do	300		4.00	
Durkee ditch	do	300	do	1,200		4.00	
Fraser ditch	do	100	Alfalfa and truck	400		4.00	
Euqua ditch	Mill Creek Slough	200	Alfalfa	600		3.00	

[1] Does not include water pumped from individual wells.
[2] Includes 1.5 cubic feet per second from artesian wells.
[3] Record thought to include days on which no water was run, indicating that quantity reported is too large.
[4] No data are available showing quantity used. The figure given does not include water pumped from wells in bed of Lytle Creek.
[5] If continued through November, as is likely, the depth will be 3.40 feet.
[6] River dry at intake and water comes from artesian wells.
[7] Record of diversions not obtainable. Based on estimated flow of 46 cubic feet per second for 180 days.
[8] Includes water pumped from company wells.

Summary of measured or estimated diversions of water from Santa Ana River and tributaries, January to November, 1912—Continued.

System.	Source.	Area irrigated.	Crops irrigated.	Total quantities diverted and used.	Maximum diversions noted.	Quantities diverted per acre.	Remarks.
Orange County area:		*Acres.*		*Acre-feet.*	*Cubic feet per second.*	*Acre-feet.*	
Santa Ana Valley Canal	Santa Ana River	17,000	Citrus fruits, 12,200 acres; walnuts, 4,500 acres; apricots, 900 acres; miscellaneous, 1,365 acres.	[1] 32,583	90.00	1.91	Crops irrigated include 1,965 acres watered from Santiago Creek and private wells.
Anaheim Union Canal	do	13,000	Citrus fruits, 11,270 acres; walnuts, 3,875 acres; miscellaneous, 3,100 acres.	[1] 26,890	61.00	2.07	Crops irrigated include 5,245 acres watered from private wells.

[1] Includes water pumped from company wells.

REDLANDS-HIGHLANDS AREA.

This area comprising 26,765 acres extends around San Bernardino Valley on the southeast, east, and north, and as shown in the table is devoted almost exclusively to citrus fruits. By far the greater portion of the area is irrigated by Bear Valley Mutual Water Co. The water is carried in lined ditches and pipes and used very economically. There is practically no riparian land in the district. Some of the companies with the best rights have no water filings, their claims being based entirely on use. The Old Town water users have early rights to three-fifths of the flow of Mill Creek. Crafton Water Co. irrigates in all about 3,000 acres, 1,200 acres being watered with 255 inches from Bear Valley Mutual Water Co. Bear Valley Mutual Water Co. delivers to companies having old rights and is the only company diverting water from Santa Ana River above Redlands. Its storage reservoir at Bear Valley Lake has recently been increased to a capacity of 65,000 acre-feet. None of the water diverted by this company in March was used, and only from June to October is the entire diversion counted as delivered to irrigators. Having perfect control of its water supply through its storage reservoirs, the company delivers a constant stream of 0.55 inch per share each 30 days of the irrigation season of 180 to 210 days, which gives an average use of from 1.07 to 1.84 acre-feet per acre. The owners of stock in the City Creek Water Co. also have shares in the Bear Valley Mutual Water Co., and as the waters from both sources are mixed the gross duty of City Creek water is only approximately correct. Besides the water used on the 320 acres mentioned, 830 acre-feet of City Creek water is applied to other lands.

SAN BERNARDINO BASIN.

This district covers the lands in the center of San Bernardino Valley. All the irrigation is from ditches from Warm Creek or springs and from wells, except a small area which is watered from San Bernardino sewage waste. Where ditches are taken from Warm Creek irrigators have court awards to definite quantities of water, there being no filings. In this district there is still considerable swamp land to reclaim by drainage and irrigation. The use of water in 1912 under McKenzie ditch began in May and was estimated to continue through November. There are some wells in this tract so that more water than was taken from Warm Creek was used. The use shown for Shay ditch is based on single gaugings in May, June, July, and August. The use by Warm Creek ditch covers the period May to October.

RIALTO-COLTON AREA.

This area includes the land about Colton and west of San Bernardino Basin and all irrigated land to the north and west taking water from Lytle Creek or from wells in its bed. Water in this area is used economically, practically all of the flow being carried in lined ditches and pipes. Heavy pumping from the gravels of Lytle Creek has reduced the water levels. Fontana Development Co. in this area is doing extensive work in storing extra water in the creek gravels. Of the water diverted by Fontana Development Co. the company has a right to only a part, the remainder going to holders of old rights, among them being the city of San Bernardino. The period of use estimated for Meeks & Daly ditch is April to October, inclusive. It was not possible to determine the area irrigated by this ditch, because the water used is owned under many rights and is used in many places, both in the Riverside and Colton areas.

RIVERSIDE AREA.

This district reaching from San Bernardino Basin on the north to Corona on the south and the mountains on the east, and embracing West Riverside, includes 27,625 acres of irrigated land. Of this 4,500 acres in citrus fruits and 1,000 acres in alfalfa are about Corona. Taken as a whole this district appears to be not as economical in the use of water as are the sections about Redlands and Rialto. Rights to water in this area are generally not based on filings but on use and court decrees. The record for Riverside Water Co. counts on no irrigation in March, November, or December and an estimated flow of 50 cubic feet per second during September and October. Water costs users an average of about $9 per acre per year, not including interest on their stock. Diversions by Jurupa ditch are by gravity and by pumps, the latter starting in 1912 on May 19. The total diversion given in the table for this ditch included a small use in January and was based on the assumption that the pumps would deliver their average quantity through October and that water would be used through November, because alfalfa is the principal crop. The record of Alvitrez ditch covered use from May through November.

SANTA ANA RIVER AREA.

In this district are included the bottom lands of Santa Ana River from below the Riverside district down the river to the point in Orange County where Santa Ana Valley Irrigation Co. begins to irrigate. The lands of this section are usually low and poorly drained, being somewhat similar to those of the San Bernardino Basin. Water is not used economically, much being diverted that is not used and later returned to the river. Two additional ditches not

mentioned irrigate about 100 acres intermittently near Rincon, and Castello ditch, another small conduit, receives about 150 inches in the winter months. Below Rincon about 324 acres are irrigated from wells, of which about 250 acres are on hillsides and in citrus fruits. Continuous records were not kept on the small Santa Ana River bottom ditches, but approximate averages were obtained from frequent measurements during the season of observation and similar estimates were made for the other months. All of the bottom lands are riparian.

ORANGE COUNTY AREA.

This district includes the lower part of the lower Santa Ana Canyon and all lands covered by ditches of the Anaheim Union Water Co. and of the Santa Ana Valley Irrigation Co. The water supply of the district is derived from Santa Ana River and wells. The Santa Ana River water used is that which rises below Riverside. Both Anaheim Union Water Co. and Santa Ana Valley Irrigation Co. use water with economy, neither company having more than a few miles of unlined canal. In addition to its diversions from the river, Santa Ana Valley Irrigation Co. pumps from three wells during the dry season to the extent of about 9.5 cubic feet per second, the pumped water being delivered along with the river water. In addition to the 17,000 acres irrigated by this company, 1,500 acres within the same general area are watered from Santiago Creek and 465 acres are watered exclusively by private pumps principally in the Tustin district. Conditions with Anaheim Union Water Co. are quite similar to those with Santa Ana Valley Irrigation Co. Under this system private pumping plants also complicate the situation with reference to the quantities of water actually used, making the duty appear higher than it probably is, owing to the supplemental supplies furnished by the pumping plants.

DUTY OF WATER.

Owing to the fact that the field investigations on Santa Ana River in 1912 could not cover the entire irrigation season, making it necessary to estimate for both early and late use, the figures in the preceding table (p. 81) do not give definite data as to the duty of water obtained. Those figures do, however, indicate in general the character of use. The employment of lined ditches and pipe-lines in the Redlands-Highlands area, for instance, results in a gross duty figured in inches of summer flow of 1 inch to 5 acres, with the depth applied during the irrigation season of 180 to 200 days varying from 1 to 2 feet. Records show that as much as 5 feet in depth is sometimes used in that area, but such practice is extremely rare and only occurs where there is plenty of water and on sandy land. In the San Ber-

nardino Basin the duty of water for alfalfa and truck varies from 2 to 4 acre-feet per acre per year, or about 1 inch of summer flow to each 2 acres. Water being somewhat plentiful there, the less economical methods of use prevail. In the Rialto-Colton area use is again more careful, practically all of the flow being carried in lined ditches and pipes. In the Riverside district only a part of the systems use lined ditches and pipe distributaries. In the Santa Ana River area use is naturally excessive on account of the irrigated land principally being along the river bottoms. Water used here above the amounts that can be absorbed by the crops readily drains back into the river and helps make up the supply of the Orange County ditches. Under both Santa Ana and Anaheim Union Canals the duty from company water is high because it is supplemented by use from private wells and because considerable areas of walnuts are irrigated in winter, leaving the summer flow for the other crops.

In order to give a better basis of judging of the economy of present use of water from Santa Ana River than would be given by the necessarily incomplete records of diversions, the quantities used on nine individual farms were ascertained. The crops irrigated on these tracts were walnuts, oranges, apricots, and alfalfa. The data obtained are summarized in the following table:

Summary of net duty of water on farms in Santa Ana River Basin, 1912.

Name of irrigator.	Source of water.	Area irrigated.	Crop irrigated.	Depth of water applied.	Rainfall.	Total depth received.
		Acres.		*Feet.*	*Feet.*	*Feet.*
G. M. Bubach	Santa Ana Valley Canal.	15.00	Walnuts	4.83	1.08	5.91
W. H. Burnham	do	20.00	Oranges	1.79	1.08	2.88
Geo. Mallory	do	18.38	do	1.52	1.08	2.60
Will Huff	do	21.00	Walnuts	3.18	1.08	4.26
C. H. Potts	do	6.25	Oranges, apricots, walnuts.	1.36	1.08	2.44
Chase and Wilson	Riverside Water Co.	31.50	Oranges	4.10	.92	[1] 5.02
Daniel Bursk	do	19.00	do	2.58	.92	[2] 3.50
E. G. Harris	do	10.00	Alfalfa	4.45	.92	[3] 5.37
H. J. Harris	do	20.00	do	4.38	.92	[4] 5.30

[1] Cost of water per acre, $16.52.
[2] Water received on $3-rate per acre from Nov. 1 to Apr. 30.
[3] Cost of water per acre, $9.50.

Averaging the amount of water applied to the various crops, the following depths are obtained: Oranges, 2.72 feet; walnuts, 3.86 feet; and alfalfa, 4.40 feet.

RIPARIAN LANDS.

Owing to the length of Santa Ana River and to the different conditions found in the three counties through which the stream passes, the study of riparian lands was not entirely satisfactory. A search of the records of the county assessors showed that in no county were

they up to date. Orange County presented the worst difficulties, the surveys there being in such shape that it was impossible to determine from them whether holdings touch the river; consequently the only data that could be obtained for Orange County are those obtained from visiting the owners whose holdings touch the river. In some cases the owners could not be located and no information could be obtained from neighbors. Information was easier to obtain in Riverside County. Using the standards adopted, 7,955 acres in this county are riparian to Santa Ana River or tributaries, 589 being irrigated and 7,366 acres being unirrigated. In San Bernardino County data were secured as to the riparian owners on Lytle Creek and Santa Ana River proper, as well as that part of Warm Creek not included in the city of San Bernardino. The data obtained show that 4,520 acres of riparian land are irrigated on Lytle Creek and 9,400 acres are unirrigated; that 627 acres of riparian land are irrigated on Santa Ana River and 7,640 are unirrigated; that 62 acres of riparian land are irrigated on Warm Creek and 391 acres are unirrigated; and that 355 acres of riparian land are irrigated on City Creek and 50 acres are unirrigated. Making the best segregation possible of Orange County, we have 1,384 acres of riparian land irrigated and 10,175 acres unirrigated, these figures not referring to any land below that watered by the Santa Ana and Anaheim Union Canals. In general, people along the Santa Ana River consider riparian rights advantageous. Companies and individuals holding land away from the river usually consider that they are riparian owners, because in nearly all cases the land now irrigated was originally a part of riparian Spanish grants.

GENERAL SUMMARY AND CONCLUSIONS.

The ultimate purpose of the investigations reported in this bulletin has been to assist in bringing about the fullest utilization of the irrigation resources of California. It is of little value to call attention to the extent of those resources or to the manner and character of their present use if by so doing the public is not at least to some extent led to bring to these resources a greater degree of protection or to their full utilization a greater degree of incentive and encouragement. The public problems connected with irrigation in California are as yet but little solved, and because this was believed to be partially due to a lack of general understanding regarding the extent of the irrigable lands, the irrigation maps accompanying this report were prepared. People in the north have not generally known of conditions in the south and vice versa, and for that reason and at the expense of fuller investigation in a few selected localities the entire State has been covered in the study.

As regards the fundamental need of protecting public irrigation rights, to the end that the irrigation waters of the State shall not only not be wasted, but that they shall bring prosperity to the largest number of farm homes, there is no north nor no south in California. Irrigators in southern California are not generally willing to admit this fact, because on the whole they use water very economically. But rights to water for irrigation have been acquired by them as by others in California only in suits between individuals, in which the State has not been represented, and it has never been appreciated generally that such procedure nearly always involves at least some public waste. Equally State wide, as has been frequently pointed out previously by both public and private agencies, is the need for a Domesday Book of vested water rights, that irrigation waters not yet really utilized, which are to be found in every irrigated section of the State, may become known and thereby become utilized. In the economy of present use of water the south is unquestionably leading the north, so that there is less need for measures that will prevent waste below Tehachapi than above it. But throughout the State education in better methods on the one hand and on the other hand the exercise of sufficient public control to keep use down to crop necessities can alone insure the kind of irrigation progress that is truly economical. If California puts into force some such method of determining and adjudicating existing rights to water as is embodied in the best modern irrigation legislation elsewhere, and as is now again proposed for California, there can be no question that it will be welcomed by actual irrigators in at least all of the sections in which development has not yet approached the maximum. This will be true even if determination and adjudication of existing rights is made possible only to communities calling for it, rather than compulsory for all communities, regardless of whether rights are already considered settled on a basis that is fair to both irrigators and the public. If in addition or independently provision is made for the exercise of public control of new appropriations, in accordance with established custom in nearly all of the other western States, an important and definite advance will have been made over the present practice in water filings—a practice that gives to many filings a color of right not justified by the actual utilization following and makes impossible any definite understanding of the amount of water that will ultimately be allowed on behalf of development already under way. Finally, if some such public distribution of diversions of water as most other irrigation States provide is provided for California, at least to the extent that it may be called into force locally when demanded by a reasonable number of irrigators concerned, a program of State control of and encouragement to irriga-

tion that was in considerable measure marked out for California by the first State engineer nearly 30 years ago will at last have been carried out, even if only after the general principles of this program have long been in effect with a high degree of success in numerous other commonwealths.

In the foregoing outline of the irrigation resources of California, the agricultural and the irrigated areas have been listed for 335 separate valleys or units, 167 of these being in northern California, 80 in central California, and 88 in southern California.

The total area of irrigable agricultural land found in the zones of irrigation water supplies, which includes all of the valley lands, the rolling plains of the Great Valley, the arable portions of the Sierra foothills up to about 3,000 feet in elevation, and all of the plateau and desert lands to which some irrigation water supplies are available, is 21,865,200 acres, of which 3,192,646 acres are already irrigated, and 9,699,600 acres are estimated as the area to be ultimately irrigated.

Of the total irrigable areas found, about 28.5 per cent are in northern California, about 44 per cent are in central California, and about 27.5 per cent are in southern California. Of the total irrigated area, about 15 per cent is in northern California, about 61 per cent is in central California, and about 24 per cent is in southern California. Of the areas it is estimated may ultimately be irrigated, about 35.5 per cent of the total are in northern California, about 44.5 per cent are in central California, and about 20 per cent are in southern California. Of the estimated future increase in the irrigated acreage of California, about 45 per cent is allotted to northern California, about 36.5 per cent to central California, and about 18.5 per cent to southern California.

The mean annual flow of the major surface streams of California in round numbers approaches 60,000,000 acre-feet, or enough to cover all of the irrigable land of the State to a depth of nearly 3 feet. But this water does not all run where or when most needed for supplying deficiencies in soil moisture in the cropped or cultivable fields; nor is the mean flow of streams the flow that measures possibilities of utilization, except as storage is available to equalize all of the years, which is the case, so far as yet known, with a relatively few streams only. So the quantity of water available for irrigation in California is very much less than the total quantity carried in the streams. If an average of 2 acre-feet per acre per year were eventually to be used on the entire area it is estimated may ultimately be irrigated, less than one-third of the mean annual flow for all the State would be required. If all of Sacramento Valley and plains and adjacent arable Sierra foothills should sometime be irrigated 2 feet deep, a quantity of water equal to only one-third of the mean outflow of Sacramento River at

Collinsville during the few years records were attempted for that point would be required. If all of San Joaquin Valley and its plains and adjacent arable Sierra foothills should be watered to the same depth, about one-third more water than now enters San Joaquin Valley would in mean years be needed. If all of the irrigable lands listed for southern California were to be covered to a depth of 1.5 feet, the full mean flow of all of the streams of southern California except the Colorado and about 3,000,000 acre-feet annually from the Colorado would be required. None of the above figures make any allowance for seepage losses in transit.

Aside from questions of irrigation methods and practices and of the values created by irrigation, the character of the present use of water for irrigation in California is outlined by the data given for the six typical streams selected, extending from the Shasta on the north to the Santa Ana on the south.

Use of water in Shasta Valley is the use of the mountain valleys where farming is subordinated to stock raising and where a multiplicity of small individual and partnership ditches, with an occasional larger ditch owned by larger interests, constitute the means of diversion. Use is as a rule exceedingly wasteful, even when measured by local standards. Water rights are those of the early appropriator and of the riparian proprietor. Litigation has been the basis of such settlements as have been made, but in important instances these have not proven satisfactory. Appropriations of water are usually considered "rights" up to the quantities mentioned in such filings as have been made, and individuals as a rule consider themselves entitled to what water they want ahead of those whose first use is recognized as subsequent, even if the water in question is allowed merely to flood promiscuously over fields of native grasses.

Along Feather River, the next stream toward the south studied in detail in 1912, irrigation now is a forerunner of irrigation that eventually will be found throughout Sacramento Valley, covering valley, plains, and foothills. The Sacramento Valley land now irrigated from the Feather has been brought under water within the past decade and is planted to the farm, orchard, and vineyard crops commonly found under all of the large gravity canals in the great valley. Delivery and distribution methods are yet relatively crude and use somewhat extravagant owing to the newness of the irrigation systems and to the large quantities of water available in the source of supply. Riparian lands here are of little significance, because their areas are mostly small, because water is plentiful, and because irrigation is new. The irrigated plains and foothill lands to which the Feather is tributary are typical of plains and foothill lands elsewhere in Sacramento Valley. Compared with the valley floor, these

lands are shallower, the more intensive cultivation of citrus and olive orchards is followed, and water requirements and the quantities used are less, the present irrigation duty in some cases equaling that of the sections in southern California in which water is used with very high economy. Conflicts in water rights on the main Feather have not yet begun, but under present conditions they are inevitable, because the low flow of the stream is below the requirements of the projects now operating or under way. Unless means are provided for determining by public authority what water each project needs and can depend upon, development must inevitably be speculative and values uncertain, with sure ultimate loss to some interests and a certain resulting increased burden for the irrigators, because the loss of an expected water supply or the cost of litigation in defending one must ultimately fall on them. There is ample water in Feather River for all land along it, but some of the water must be stored. Some of it is now in process of storage for power purposes, but under present conditions, possibly outside of those who are building the storage and who thus far have no irrigation interests, no one can be sure of rights to that stored water, nor is it possible for those who might plan to divert it to foresee when an injunction may be brought against them. Increases of irrigation on the plains must depend largely on pumping or expensive gravity diversions, and there would be much more encouragement to those who will some day undertake such pumping or gravity diversion if they could know in advance what water rights could surely be depended on.

The two typical sections of central California in which special irrigation studies were made in 1912 represent both the major and minor valleys of this third of the State. The largest future irrigation increases in central California will be made in the portion of San Joaquin Valley north of Fresno, watered by San Joaquin River and its tributaries, while Santa Clara Valley indicates the character of irrigation development, viz, pumping from underground sources and greater spring and winter use of surface streams, that will take place in the central coastal valleys.

Irrigation along San Joaquin River and its east side tributaries ranges from the rather uneconomical flooding of pasture lands in large holdings to the more economical watering of fruits, alfalfa, and other cultivated crops found on the 10 and 20 acre diversified farm. A quarter of a million acres of riparian land lie along the main San Joaquin and its sloughs and Fresno Slough. If, as firmly believed by some, it would be advantageous to clear up uncertainties as to what the limits of riparian land in California are, the riparian conditions here offer ample illustration of the difficulties of doing so, for a careful search of all related official records, including numerous court decisions, dis-

closed so many discrepancies and uncertainties that a plan to plat the riparian lands along this stream on the accompanying map of a part of San Joaquin River had to be abandoned. If large quantities of flood waters now annually go to waste in California through lack of storage or the largest possible use in times of plentiful stream flow, then they do so here, where streams capable, with full economical development, of irrigating about 2,000,000 acres, in 1912 irrigated only 503,317 acres, of which more than 126,000 acres was flooded grazing land. On the main San Joaquin years of expensive litigation have not yet brought final court decisions on important irrigation rights, and on this stream the results of the litigation, whether just or unjust, are less satisfactory to the local public than on any other stream studied in detail. The studies in 1912 indicate that some of the use by the larger interests is less wasteful than popularly supposed and that much of the pasture land uneconomically flooded receives water only in the periods during which the flow in the river is in excess of all of the present means of diversion. On the other hand, considerable quantities of water are used during low-water periods on pasture lands that a development involving more settlers would transfer to higher uses. Use of water on the tributaries of the San Joaquin is in some instances really only just beginning, as on the Stanislaus, the Mokelumne, and the Calaveras. On the Tuolumne it is a comparatively recent development, yet so far advanced that lack of storage is already retarding growth. On the Merced difficulties that almost invariably have attended private control of large irrigation supplies have kept progress down to less than one-tenth of what may ultimately be possible.

Irrigation as practiced in Santa Clara Valley is the irrigation that generally comes only when the advancing age of unirrigated orchards and the decreasing prices of their products tend to bring the farmers' annual balance sheet near the danger point. Fifteen years ago practically no orchard lands were artificially watered in this valley. Now the value of irrigation water is very generally recognized and, especially in years of low rainfall, costly efforts are sometimes made to obtain a supply, and this in spite of the paradoxical condition which finds some orchardists who once irrigated now ceasing to do so. Troublesome riparian rights here have been largely eliminated by their purchase in the interests of domestic water supplies, and the use of spring and winter surface supplies in direct irrigation, which is possible on a large scale in many sections of the State, has advanced further here than in any other part of northern or central California.

Santa Ana and Santa Clara Rivers, the two typical southern California streams selected for special study in 1912, not only indicate differences in irrigation conditions from those found in northern and

central California, even if these differences appear from the irrigation institutional standpoint to be more in degree than in kind, but they also point to differences found within southern California. Irrigation conditions on Santa Clara River are but a brief step from those of developed sections farther north, while those on the Santa Ana range from the highly economical and specialized use on some of the citrus orchards about Riverside and Redlands to the more general, even if equally economical, use about Orange and Anaheim, and to the somewhat excessive use in limited areas in the Santa Ana River bottoms. On the Santa Clara supplies are thus far generally considered ample and water-right litigation has not been prominent, although there is apparent need for determination and final settlement of rights before matters become acute, as they must as irrigation comes more to be considered a necessity than an aid. On the Santa Ana much litigation is said to have settled rights with some degree of satisfaction to the major interests present, although litigation is sure to continue even if the main rights on the stream should not be seriously involved. On both the Santa Clara and the Santa Ana the subdivision of the riparian grants has greatly reduced the areas of individual holdings bordering on the streams and riparian in the sense that they are the least parcels of land so situated. On the Santa Clara about 26 per cent of the total irrigated area is riparian land, while on the Santa Ana the irrigated riparian area is only about 8 per cent of the total area watered.

The detailed studies of the use of water in 1912 in the six typical sections selected for special investigation were not intended to furnish data regarding the quantity of water needed by the various crops in the various localities and under the various conditions in the State. The full season of use was not available for study, nor, with the means available, were the refined methods needed in studying water requirements possible over the extensive area covered. But these studies show approximately the general duties now obtained in California with irrigation water. In Little Shasta Valley as much as 4 or 5 acre-feet per acre was about the average diversion between April and August, inclusive, and under two ditches more than 7 and 12 acre-feet per acre, respectively, were diverted, and this in spite of the fact that additional water was run both before April and after August. As might appear, all of this water was not really used on the lands to which it was diverted, because much of it was run for long periods over meadows, the run-off going to other meadows below. On the Feather or its tributaries the average diversion by the largest gravity canal was 7.53 acre-feet per acre from May through October, while the averages for the two systems next smaller were 6.06 and 5.83 acre-feet per acre, respectively. On the other hand,

the quantities actually used on nine typical farms varied from 0.75 acre-foot per acre on a sandy loam prune orchard for which the water supply was pumped to 2.72 acre-feet per acre on a clay loam alfalfa field under Sutter-Butte Canal, not counting a 50-acre rice field on which 5 acre-feet per acre were used.

On the east-side tributaries of the San Joaquin the diversions per acre by about 20 systems ranged from 1.50 acre-feet by ditches supplying water mostly to vineyards to 12.45 acre-feet by the largest canal. On the main San Joaquin the range of averages was from 0.5 acre-foot under one of the large pumping plants to 3.08 acre-feet used during high water under a canal irrigating 8,000 acres of pasture. Under the main west-side canal from San Joaquin River the average diversion per acre was 2.75 acre-feet, while the actual use on 31 typical tracts in either 1910, 1911, or 1912, ranged from 0.85 acre-foot per acre on an alfalfa field of heavy soil to 3.88 acre-feet on an alfalfa field of sandy soil. In Santa Clara Valley, Santa Clara County, the spasmodic diversions from surface streams varied under the ditches getting substantial amounts from 2.30 to 4.39 acre-feet per acre. In Santa Clara River Valley the average diversions per acre in 1912, from April to October, inclusive, ranged from 0.76 acre-foot under a ditch watering 1,400 acres about equally divided between citrus and deciduous fruits to 15.10 acre-feet under a small ditch watering 40 acres of alfalfa, much of the water of the latter ditch being returned directly to the river. Net figures of actual use on typical farms along this river show depths applied ranging from 0.46 acre-feet on beans to 2.74 acre-feet on lemons and 6.21 acre-feet on alfalfa. Along Santa Ana River the diversions varied between January and November, 1912, from 1.31 to 2.96 acre-feet per acre under systems irrigating citrus fruits, alfalfa, and miscellaneous crops, and from 2.04 to 6.45 acre-feet per acre where alfalfa was the main crop watered. Nine individual farms under Santa Ana systems on which net use was ascertained in 1912 gave duties ranging from 1.52 to 4.10 acre-feet per acre for oranges, averaging 2.72 acre-feet; from 3.18 to 4.83 acre-feet per acre for walnuts, averaging 3.86 acre-feet; and from 4.38 to 4.45 acre-feet per acre for alfalfa, averaging 4.41 acre-feet.

Studies of the actual water requirements of irrigated crops in California have been in progress as limited funds have been available and mostly under cooperative agreement between the irrigation investigations and the California State engineering department for the past 10 years. While these studies have not yet progressed far enough to give final data, they already show that the best economy demands limiting the quantity the State should allow, in so far as the State has authority to check excessive use, not to the quantities irrigated

soils can absorb, but to the quantities irrigated crops can use. Speaking in the interest of the public, which in the end is paramount, "beneficial" use in irrigation can only be considered use that helps plants to grow and produce. Only a realization and an enforcement of this principle can bring about the irrigation of the nearly 10,000,000 acres of California agricultural lands that it is estimated in this report may ultimately be watered.

There are many sides to the future irrigation development of California, and in the end the equitable and orderly distribution and delivery of water to actual users will transcend in importance matters of even the public control. But equitable and orderly distribution and delivery of water for irrigation are not possible unless rights to water are certain, and it is believed that results will fall far short of the possible and practicable unless the public of California give the same measure of attention and support to irrigation that the public of other Western States have given to irrigation within their jurisdictions.

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